THE ENGINEER.

Harland and Wolff's Works at Belfast.

HARLAND AND WOLFF'S WORKS AT BELFAST.

IT is difficult to understand how anyone should have decided, in the first instance, to start steel shipbuilding in Belfast. Granted that its position so far as access to the sea is concerned is suitable, there remains the hard fact that practically every ounce of material required in the construction has to be imported. Ireland may be area covered by the works was about 3¾ acres, today they spread over more than eighty acres. In 1859 they employed 44 men, now they find work for 12,000. How great a change there has been even since the year 1879 may be gathered from a comparison of Figs. 1 and 2, the latter of which shows the area covered at that time, and the first the extent of the works at the present day. Two or three years after starting, Mr. Harland was joined information regarding the management which we must give. Lord Pirrie, as chairman of the company, is in supreme command, and under him, each being responsible for one particular department, are six directors—the Right Hon. A. M. Carlisle, general manager; Mr. W. J. Pratten, consulting engineer; Mr. J. W. Kempster, electrical engineer and expert; Mr. T. Andrews, naval architect; Mr. G. Cuming, managing engineer; and Mr. R.

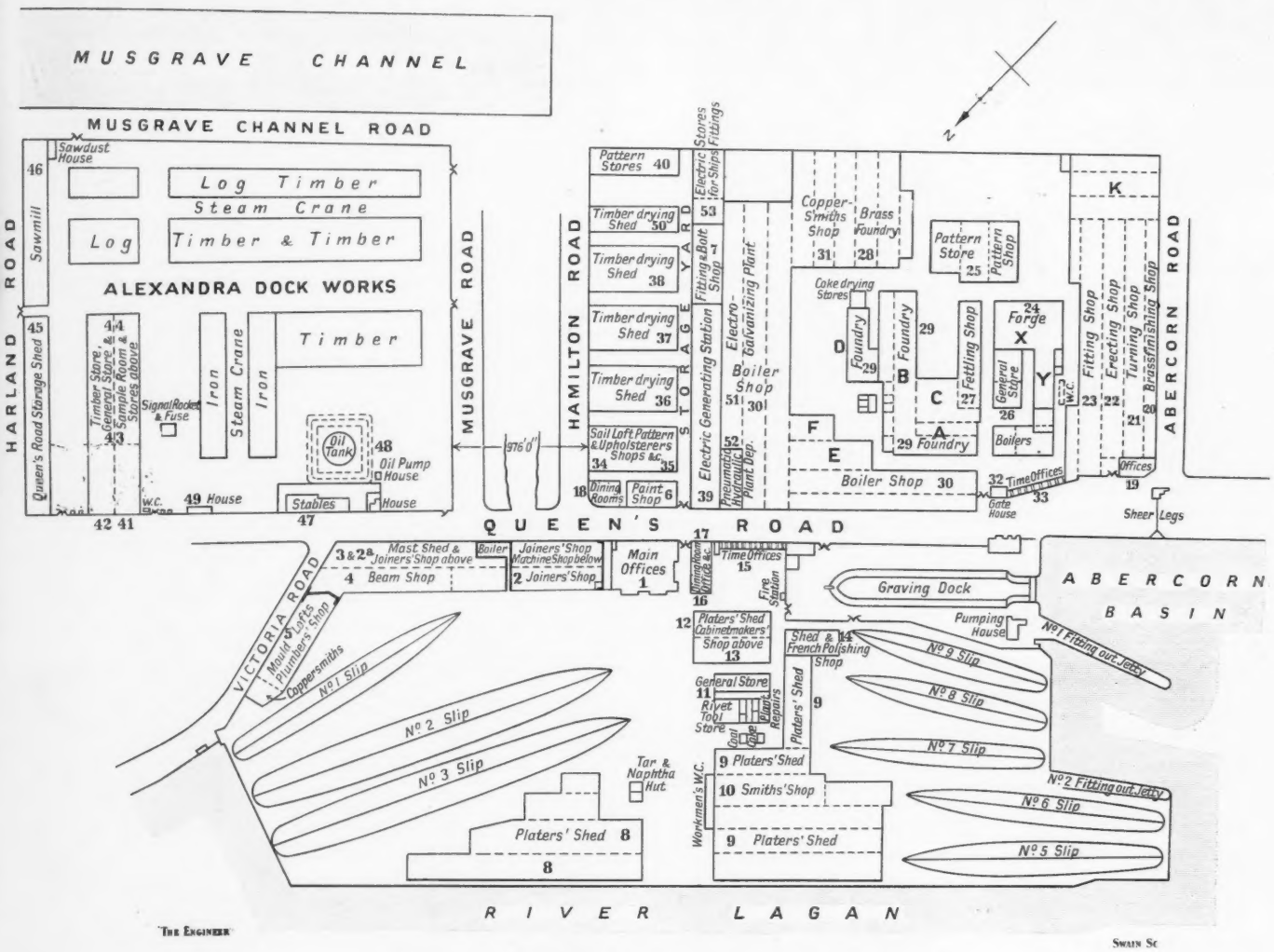


Fig. 1—THE PLAN OF THE WORKS AT THE PRESENT DAY

1. Main offices
2 Joiners' shop
2a ,, ,,
3 Mast shed
4 Beam shop
5 Mould loft & plumbers' shop
6 Paint shop
7 Fitting shop
8 North platers' shop
9 West platers' shop
10 Smiths' shop
11 Stores
12 Platers' shop
13 Cabinet shop
14 Polishing shop, &c.
15 Time offices
16 Engineering drawing-office, assistant manager's offices, &c.
17 Dining room, counting house, &c.
18 Foremen's dining hall
19 Admiralty and Company's Inspectors
20 Brass finishing shop
21 Turning shop
22 Erecting shop
23 Engine fitting shop
24 Forge
25 Pattern shop
26 Stores
27 Fitting shop
28 Brass foundry
29 Iron foundry
30 Boiler shop
31 Coppersmiths' shop
32 Gatehouse and assistant manager's offices
33 Time offices and engine works
34 Spar and riggers' shed
35 Sail loft, pattern shop, and boat shed
36 Timber drying
37 ,, ,,
38 ,, ,,
39 Electric generating station
40 Pattern stores & photo room
41 & 42 Storage sheds
43 Timber and general stores
44 Sample room and stores
45 Storage shed
46 Saw mill
47 Stables
48 Oil pump house
49 Caretaker's house
50 Store for long-cut timber
51 Hydraulic department
52 Pneumatic plant
53 Electric stores for ships' fittings

regarded as producing no coal, no iron, and no copper. It has no works to make plates, even if the iron and the coal were there. It must, in fact, have seemed almost like madness when Mr. E. J. Harland—as he then was—put up in 1859 the first shops of what was to become, and is now, one of the finest shipbuilding works in the world. This must have seemed all the more so as a large portion of what is now covered with busy shops was simply a swamp, and what was not actually a swamp was river silt and mud. Yet that Mr. Harland knew perfectly well what he was doing is amply evidenced by the wonderful position which this large Belfast shipbuilding firm holds at the present day.

The history of the firm of Harland and Wolff may be outlined in a very few sentences. The works were originally started by Mr. Edward J. Harland in the year 1859—just fifty years ago, so that in this year 1909 the firm celebrates its jubilee. In the first-named year the by Mr. G. W. Wolff. These two worked together alone till the year 1874—thirty-five years ago—when three others were taken into partnership—Messrs. W. J. Pirrie, W. Wilson, and A. Wilson. The last named of the three retired shortly after joining the firm. In 1895 Sir Edward Harland died, and in 1904 Mr. W. Wilson died also. Mr. Wolff retired some two or three years ago, and sold out his interest. Lord Pirrie, as he became in 1906, now alone remains of those we have named, and he is chairman and principal in the business, which was turned into a limited liability company some twenty years ago. The capital of the company is £600,000, divided into 600 shares of £1000 each.

Such, then, is the history in brief of the company. A volume might, in reality, be written upon it, and upon the men who have made it what it is; but our business is not so much with the men as with what they have produced. Before going on to this, however, there is one piece of Crighton, manager of the new works at Southampton.

The chairman of these directors is the Right Hon. A. M. Carlisle, and on him devolves largely the general management of the whole business. It would be improper for us in any way to particularise, but this we may be permitted to remark, namely, that Lord Pirrie has as his immediate supporters an uncommonly able body of men, who are accustomed to do and, if need be, to dare.

Having regard to the fact that this is the jubilee year of the firm, and that recently very considerable additions have been made not only to the works themselves but also to the shipbuilding facilities, the present time would appear to be remarkably suitable for putting a description of this establishment before our readers; and this we propose to do in the following special article. We have recently been afforded every facility for obtaining particulars of the works, and we desire at the outset to tender to Messrs. Harland and Wolff, and to all the

members of their staff with whom we had the pleasure of coming into contact, our sincere thanks for the kindness and courtesy with which we were received on every hand, and for the readiness with which all the information for which we asked was supplied to us.

In describing an undertaking such as that of Harland and Wolff, Limited, there is always the difficulty of where best to begin. Perhaps, however, the most rational course is to start with the offices. It will not be necessary to describe them in detail, but there are certain points in connection with their arrangement and management which well merit attention. Dey time recorders are used throughout for all the officials and clerks. The work is divided up into five main departments, and in order that the letters as they arrive may be delivered promptly to that department to which they severally

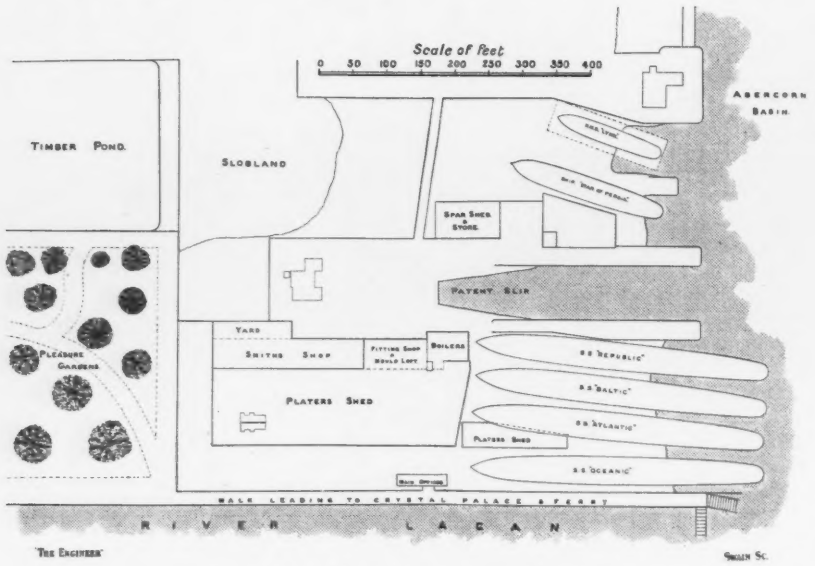


Fig. 2—THE WORKS AS THEY WERE IN 1879

are directed, four secretaries are employed, whose duty it is to read through these letters and sort them, stamping them with a separate mark and number and placing them in movable receptacles, which are taken at frequent intervals to the departments to which they belong. There is a central telephonic and telegraphic exchange, through which all messages, whether they be for the outside or whether they are inter-departmental, must pass, and copies of such messages which are going out of the works are kept and filed. This exchange is kept private, and no one who has not special business in it is allowed to enter it.

The various departments have, of course, their subdivisions, and each sub-division has its own room. Thus in passing along a well-lighted passage-way with rooms on either side divided off with partitions which do not reach to the ceiling one reads on glazed doors such inscriptions as "Shipbuilding," "Cashier," "Steel and Iron," "Works," "Stores," "General Office," "Engineering," "Paints," "Timber," "Letters," "Admiralty," "Drawing-office," &c. The staff numbers between 400 and 500. Views of one of the finest rooms in the offices, and of one of the drawing-offices are given in Figs. 4 and 5, page iii.

There are various drawing and designing offices, but we need not draw special attention to these, though we must not forget to mention a clever device which has been designed by Mr. Carlisle for use in the department where the plating of vessels is worked out. It is the custom of Messrs. Harland and Wolff to construct in wood a longitudinal half model of each vessel which they are about to build. These models are constructed to a scale of ½in. to 1ft. In times gone by it was possible to manipulate these models and to turn them into the positions required by the plating designers by hand, but the sizes of vessels, and hence of the models, has of late increased to such an extent that it has become necessary to provide a special frame in which they might be mounted turned to and held at any desired angle. Such an apparatus was designed by Mr. Carlisle, and was in use at the time of our visit. It consists of an oblong table on which the model is mounted about breast high. By an arrangement of worm and worm wheel, gear wheels and racks, the model can be revolved on its longitudinal axis, and stops in any position in which it may be placed. The advantage of an apparatus such as this will be realised when it is said that the half model of a vessel like the Olympic weighs nearly ¼ ton. Ordinarily it would require about eight men to shift it.

The works themselves are exceedingly well situated, as will be realised on reference to the map—Fig. 3, where the area covered by them is coloured full black. They are built on what is called Queen's Island, on one side of them being the Victoria Channel, and on the other the Musgrave Channel. Both of these unite in the New Channel, which has direct access to Belfast Lough, and thence to the sea. It will therefore be appreciated that though all the raw material has to be imported, there are, at least, excellent facilities for receiving and unloading it on its arrival. For practical purposes the works may be considered as being divided into two separate parts—(1) shipbuilding, and (2) engineering.

In discussing the plan—Fig. 1—it will perhaps be as well to adhere to this classification. In this way we shall be able to deal with each portion with reference to the number it bears in the books of the firm. These numbers, from 1 to 53, will be found to be reproduced on the plan.

No. 1 has reference to the main offices, and to these we have already drawn attention. Shop No. 2 is devoted to joiners' work, the shop being divided into two bays with a gallery. In this shop—Fig. 6—all sorts of wood constructional work in connection with shipbuilding is carried out, including doors, partitions, &c. On the ground floor the tools comprise saws, planers, drills, moulding machines, &c., while the gallery is devoted to much the same class of work, and has very much the same class of tools. We noticed that the Cyclone exhaust system was fitted to the machines for removing the sawdust, &c., and we shall have something to say later on as to the way in which this waste material is dealt with. This shop is constructed of a wood framework covered with corrugated iron.

Shop 2A is placed over shops 3 and 4, which are immediately to be mentioned. It is also devoted to joinery and cabinet-making, and contains such machines as saws, drills, planers, &c. In this are made, besides other things, the lavatory arrangements for cabins, and a great deal of other kinds of wood work, mouldings, &c.

Shop No. 3—see Fig. 7—is the mast shed, which at the time of our visit was devoted entirely to the manufacture of steel masts; one mast in particular, that for the Megantic, one of the two first boats with which the White Star Line is to enter on the Canadian service, being especially noticeable by reason of its great length and its graceful tapering form. Adjoining the mast shed is the beam shop, No. 4. Here beams, rails, plates, angles, cement, &c., are stored. There are two overhead electrically-driven and hand cranes, and lines of standard gauge rails traverse the shop, which has a concrete floor throughout. The building is of wood construction, with a roof of the same material, and there is an annexe to it made by fish-bellied girders carried on cast iron uprights, and here there are punching, shearing, riveting, and other machines necessary for the special work to which this shop is devoted.

Shop No. 5 has a plumbers' shop below and the mould loft above it—Figs. 9 and 8. In the latter, which has a splendid floor, the lines of the vessels are laid out, and at the time of our visit an object of interest was the setting out of the rudders for one of the large White Star liners. In the plumbers' shop below every kind of plumbing and pipe work is carried out. The machinery, which is all electrically driven, comprises cold saws, punching and shearing machines, screwing, drilling, and bending machines, lathes, and jib cranes. There is a number of smiths' fires, the blast for which is provided by a Gunther blower driven by an Allgemeine motor of 5 horse-power, and the fumes are carried away by an arrangement of ducts placed overhead. The motive power for the tools is obtained from one motor, which is suspended from the ceiling of the shop. Narrow-gauge lines run in different directions in the shop. Here we may usefully mention that there is connection with the railway systems in Ireland by means of lines laid down Queen's-road, which branch into all parts of the works and yard.

Shops Nos. 6 and 7 refer more properly to the engineering side of the works, and although they come next in numerical order, we may well defer reference to them until later, and we come, therefore, to shop No. 8, which is an entirely new erection, and which is furnished with a very excellent series of tools. It is one of several platers' sheds, and it has been newly erected because part of the site which was occupied by the shop the place of which it has taken was required for the construction of slips Nos. 2 and 3. Shop No. 8 is known by the name of the north platers' shed, and it is of wood construction. It contains numerous heavy punching and shearing machines, each with its own motor and jib cranes, each jib having a scale balance beam with tackle for dealing with plates, &c. We noticed also a fine angle-bending machine by Hugh Smith and Co., of Possil Works, Glasgow, and also a large hydraulic shearing machine, by J. Cameron, of Manchester. Very noticeable too were two plate rolls, both of them made by Shanks. One of these could take in work up to 30ft. wide. The two machines were driven off a countershaft, which itself received its motion by means of seven ropes from a 100 horse-power three-phase Westinghouse motor mounted on a concrete pier. The further equipment of this shop includes punching and shearing machines—the majority being by J. Bennie, of Glasgow—manhole and portbole presses, hydraulically worked; and numerous jib cranes for dealing with the work passing through the shop, and for carrying the hydraulic riveters. Pneumatic hoists are arranged near many of the machines. We must not forget to mention an exceptionally fine right-angled plate planing machine by Hetheringtons. This is provided with hydraulic grippers for holding the plate, and has two motors for working the tool carriage on either arm of the right angle. A scarfing and bevelling machine by Shanks also calls for special mention, as also do a large and a smaller hydraulic plate bending machines by Hugh Smith. There are also angle straightening machines, drilling and recessing machines, and a number of other scarfing and shaping machines by Hugh Smith, A. and W. Smith and Co. It may be explained that this shop is intended to supply material for the vessels which are built on slips 1, 2, and 3, and is, therefore, well placed as regards situation. It is served by a network of narrow and standard gauge lines, the floor in parts being of cobbles and in others merely of beaten earth. There is a large marking-off floor, and large hammering beds for hot bending, &c. The outside of this shop is equipped with various hydraulic and other cranes for dealing with the materials as they go in and out, and near by is a powerful revolving hydraulic jib crane for lifting material off or on to trucks wheeled underneath its jib. The space between this shop and shops Nos. 9 and 10 is taken up with stores of angles plates, &c. Tar and naphtha storage sheds are also given a position here. Views in and about the north platers' shed are given in Figs. 12, 13, 14, and 15.

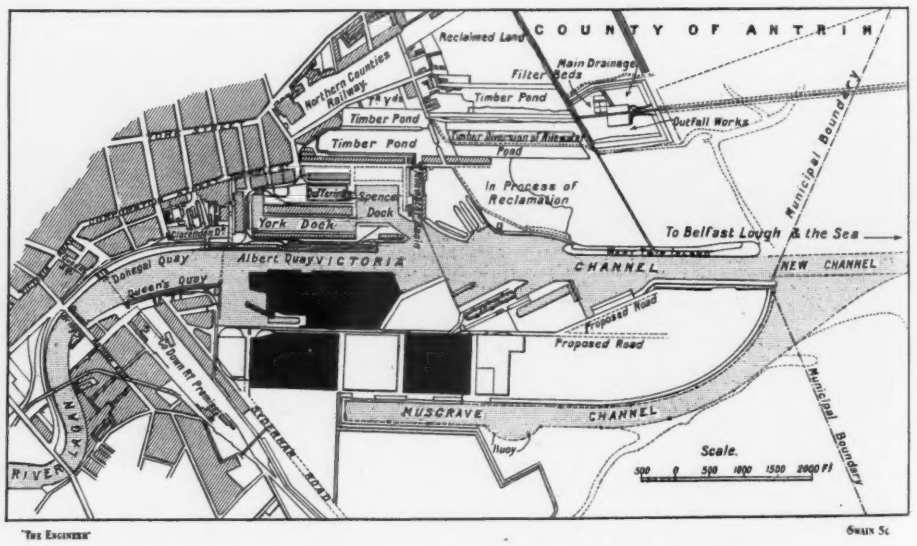


Fig. 3—THE POSITION IN BELFAST OF HARLAND AND WOLFF'S WORKS

Shops 9 and 10 are the west platers' shed and the smiths' shop, and they may for the purposes of description be regarded as a single shop. They are intended to provide for the wants of slips 5 to 7 inclusive, and they belong to the older part of the establishment. Their equipment cannot, however, in any sense be described as old-fashioned, because it is not, and it contains some very fine tools indeed. They are for the most part similar to those which we have described as being in shop No. 8, and such as are usually found in shipbuilding works. Many of them have their own separate motors, but in one noticeable case a number of tools are run from a countershaft, which is itself driven off by eight ropes from a 100 horse-power three-phase motor working at 440 volts and 600 revolutions per minute. It was supplied by the Westinghouse Company, and is mounted

on a concrete pier. Other tools besides those already mentioned are a forging machine, with its own furnace; a specially fine triple punching, shearing, and stamping machine by Bennie; a large plate edge planing machine by Hugh Smith; drilling and countersinking machines; and a large oil rivet furnace. A particularly interesting machine is a heavy plate bender made by Hugh Smith. This is hydraulically worked, and comprises a long cylindrical shaft carried in bearings on rocking arms. The plate to be manipulated is held in between grips by a series of wedges, which are pushed up a number of inclines by hydraulic cylinders. The bending is brought about by the shaft above mentioned being made to bear against the plate when it is held as above described. There is a large equipment of furnaces and bending rolls of various sizes, and angle iron benders and straighteners of different sizes. Standard and narrow-gauge lines of railway traverse the shop in all directions. The shop itself is of wood construction—see Fig. 10. There is no overhead crane, but there are numerous jib cranes, some of these being provided with hydraulically worked monkeys. The smiths' portion of the shop, Fig. 11, which is practically surrounded by the platers' shop, has a large number of smith's hearths—between forty and fifty of them. The blast for these is provided by means of a Roots blower, and the products of combustion are removed by means of a fan and a series of trunk pipes. Another part of the equipment consists of six pneumatic hammers, which we saw doing most excellent work. The tools are mostly drills, while there are numbers of jib cranes. In this shop a quantity of iron of various shapes and sizes is kept on racks of somewhat peculiar form.

Shop 11 is a general store and calls for no comment. Near by is shop 12, which is another platers' shed, and it occupies the bottom floor of the building marked 12 and 13 in the plan. Its special office is to supply the wants of vessels being built on slips 8 and 9. Its equipment as regards tools is practically the same as that of shops 8 and 9; that is to say, that it contains punching, shearing, and scarfing machines, plate-edge planers, bending and straightening rolls, grinders, drills, &c. Most of the tools are worked off a counter-shaft, which is driven from a 100 horse-power motor by means of eight ropes. Part of the power of this motor is utilised in shop No. 13, which is over shop No. 12. It is a nice, well-lighted shop, divided into two bays with a corrugated iron roof carried on light angle-iron principals resting on the sides, and on a central row of cast iron pillars. By night it receives its illumination from a series of enclosed arc lamps. In this shop are carried out all sorts of woodwork required in the internal fitting up and decoration of ships, and we may say that some of this is of the most elaborate and ornamental description. The tool equipment of the shops includes power-worked saws, planers, moulders, lathes, &c., and there is here again an arrangement by means of which the dust is sucked into ducts over the machines, so as to prevent its getting into the shop. The building marked 14 consists of two floors, the lower of which is an offshoot of platers' shop No. 12, the upper floor being devoted to French polishers.

Of the remaining buildings in this portion of the works No. 15 is the time office, through which the men employed in the shipyard pass to their work; No. 16 contains an engineering drawing-office, and the office of the assistant manager, &c., while in No. 17 is the luncheon room, &c., which is used by the chief officials.

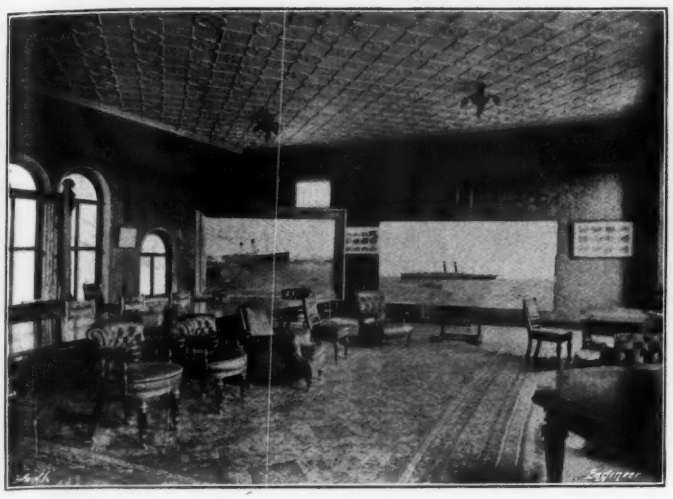


Fig. 4—THE CONSULTATION ROOM

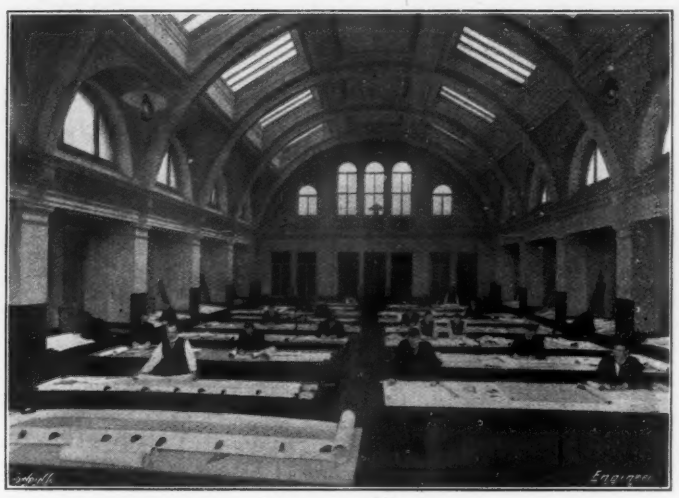


Fig. 5—SHIPYARD DRAWING-OFFICE

The foregoing completes the list, and gives a brief description of the buildings in this part of the works, but it is very far from exhausting all the subjects of interest which are to be found there. Indeed, it may well be said that the more interesting portion remains to be described, for this contains the various building slips with their erecting gantries. On reference to the plan it will be seen that there are three slips on the left-hand side, these being numbered respectively No. 1, No. 2, and No. 3. At the time of the building of the Oceanic—that is to say, some ten or eleven years ago—there were four slips here, but they were all of the same size as and parallel to slip No. 1. Neither of the four slips was long enough or wide enough to accommodate the liners of the present or immediate future, and it was therefore decided to do away with three of them and to construct two new slips, Nos. 2 and 3 in their place. These had to be made at a slightly different angle, which also necessitated the removal and re-erection of platers' shed No. 8, and their construction is interesting for a number of reasons. In the first place, over each of two of the original slips, which have now disappeared, there was a walking gantry. As the span of these was not sufficient for the new slips, it was decided to transfer them to slip No. 1, where there was already a similar gantry, so as to make a total of three on this slip. This in itself was no light task. The gantries run on twelve wheels on each side, there being also a double line of rails, 6¾ insides wide, placed at 100ft. centres on each side of the slip for them to run on. Each gantry has two hydraulic jib cranes and cross traversing travellers, and the height to the underside of these is 110ft. The overall dimensions of the whole thing were 123ft. wide, 58ft. broad, and 125ft. high, and the total weight to be moved was something like 600 tons each. The method of shifting them is well shown in the accompanying engravings. First of all a running path or slipway had to be built at right angles, or nearly so, to the original slips, then special trolleys were constructed as shown in Fig. 35, and two lines of double rails were laid at the lower end of the slips for these to run on. The gantries were then jacked up until these trolleys could be run under them, and the former were then lowered on to the latter. The engraving—Fig. 36—shows the lower part of one of the gantries resting on one of these trolleys, which were sufficiently high to raise the running wheels of the gantry well off the ground and the temporary line. Struts were fixed between the lower parts of the legs of the gantry so as to prevent these either spreading or approaching one another, and the process of moving was then carried out, this being performed by means of electric winches. We understand that in each case the operation—see Fig. 34—was performed successfully and in a wonderfully short space of time—under an hour.

The new gantry is a magnificent piece of work, not only in design, but in construction and equipment. It was primarily designed by Messrs. Harland and Wolff, and constructed by Sir Wm. Arrol and Co., Limited, the crane equipment, which is all electrically worked, having been supplied by Stothert and Pitt, Limited. We have already alluded to it in our issue of 12th June, 1908, and, as we explained then, we called it a gantry simply because there was no other word for it in our language; but a gantry in the true sense of the word it is not, for it is a fixed structure made for other things to move about on. In the issue above referred to we gave an outline drawing of this huge erection, and we reproduce it herewith in Fig. 51. It does not—nothing could—give a real idea of the dimensions of the erection, but it will serve to make the following description the more clear. We are also enabled to reproduce one from a series of progress photographs which were taken at frequent intervals during the erection, and a view of the completed gantry itself, but even these fail to give an adequate idea of its real size—see Figs. 48 and 53. It has to be seen and to be closely inspected in order to be properly appreciated. However, we will endeavour to give some idea of it in what follows. To begin with, the area covered exceeds 840ft. long by 270ft. wide. The overall length of the structure is actually 840ft. and the diameter of the circle covered by the largest crane is 270ft., but the foundation work extends beyond these dimensions in all directions, while the highest point from ground level is something like 180ft. Imagine three long lines of tall steel lattice towers running parallel to one another at a distance of over 120ft. between the lines. Each line consists of eleven towers placed at 80ft. centres. Because the ground of a launching berth is not level, these towers are not all the same

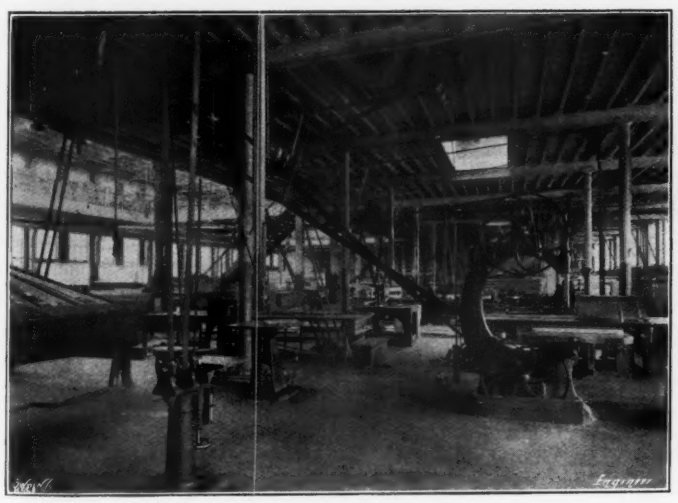


Fig. 6—THE JOINERS' SHOP

Fig. 7—THE STEEL MAST SHED

height, but the shortest is about 160ft. in height and the longest some 180ft., and the tops of all of them are at the same height, so that a series of lattice girders placed on their tops, and running longitudinally, forms a horizontal road, and along the road so formed on the centre line of towers runs a crane of the Titan type, which has an outreach of 135ft., and can deal with a three-ton load at this radius, or with a load of five tons at a radius of 65ft. Ships practically 1000ft. long could therefore be dealt with did the need arise. In addition to being connected together by these girders longitudinally, there are cross girders which connect the tops of each of the towers in the outside rows with tops of the corresponding towers in the centre row, the whole structure being therefore securely braced together. Nor is this all, for what are practically other deep girders—they are over 30ft. deep—run along the inside of each outer row of towers and along both sides of the centre row, so that their tops are rather under 30ft. below the tops of the towers. The purpose of these girders, in addition to giving strength, is twofold: first to provide a road for overhead 10-ton travelling cranes, and next to form a means of supporting a number of 5-ton walking jib cranes. Of the latter there are in all ten, two of them running on each side of the centre row of towers and to form the foundation of each tower, and these were braced together and filled in solid with concrete. For the floor of the berths the same sorts of precautions had to be taken. Piles spaced about 4ft. apart were driven in rows, which were also about 4ft. apart, the piles in two adjacent rows being staggered. Along the centre line of each berth where the keels of the enormous vessels will be laid, the piles have been driven closer together. The whole surface has then been covered with concrete, in some cases to a depth of as much as 4ft. 6in., this mass of concrete embracing the heads of the piles, which were not driven down to the level of the ground but were left projecting 1ft. or 1ft. 6in. The highest point in the floor of the berths comes at a point coincident with the bottom of the third tower from the landward end, that is to say, some 240ft. or 250ft. from that end of the gantry. From this point there is a regular slope in both directions—forward and aft—of $\frac{1}{8}$in. in the foot. Laid on the concrete floor there are two lines of narrow gauge tramways on each side of each berth. These are provided with deep tramway section rails, and are furnished with crossovers. There is at present a cofferdam at the water end of each slip.

On the other side of the shipyard, and between berths 5 and 6, there has been at work for some years now a laid on the top of the longitudinal girders already mentioned is a double cantilever crane which has a total outreach of 115ft. on each side. This crane cannot revolve, but from end to end of it—or nearly so—runs an electrically-worked trolley, which has a total travel of 217ft.—108ft. 6in. on either side of the centre. The height to the underside of the arms of this crane is about 150ft. Its trolley can deal with a weight of 5 tons at a radius of 108ft. 6in. The speed of hoisting is from 200ft. to 250ft. a minute. The trolley can travel at speeds varying from 400ft. to 800ft. a minute, and the crane itself from 400ft. to 600ft. a minute, against a pressure such as would be caused by wind blowing at 30 miles an hour. The jibs first mentioned can deal with loads of 10 tons at 102ft. radius, and 20 tons at 62ft. radius. A view of this crane is given in Fig. 52, and a drawing in Fig. 50.

We have said that there are in all ten uprights to this gantry. In the middle of its length, that is to say, with five uprights on either side of them, there are two sets of A shaped bracing and anchoring pieces. These cover a span of some 120ft. at ground level. The bottoms are carried in pin joints, and the inclined uprights are braced in the same way as the others. It will be gathered that as this A piece is fixed expansion of the whole gantry is

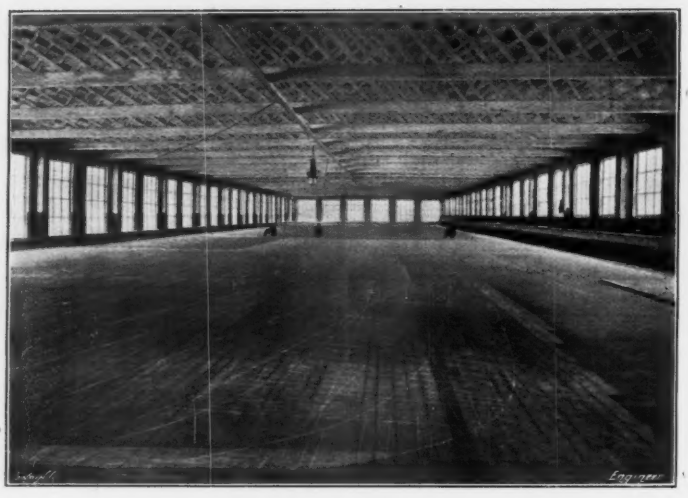


Fig. 8—THE MOULD LOFT

Fig. 9—THE PLUMBERS' SHOP

Fig. 10—INTERIOR OF WEST PLATERS' SHED

Fig. 11—SMITHS' SHOP IN WEST PLATERS' SHED

three on the inside of each of the side rows. The height from the underside of these crane hooks to the floor of the berth is 113ft. There is a continuous line of rails for these cranes from end to end of the structure, so that there is nothing to prevent them being brought together at either end, or, indeed, at any point where they may be required. Working above these, and spanning the whole width of each berth, are three travelling frames, each carrying two 10-ton crabs. This makes a total of six 10-ton cranes to each berth. The lines on which these cranes run, as in the case of those for the walking cranes, extend for the full length of the gantry. The full height to the underside of their hooks is 126ft., and this is the governing feature as to head-room, for the jib cranes, though lower, can be swung out of the way. These cranes are all electrically worked. The jib cranes run between two single rails on four wheels, and the travellers are carried on four four-wheeled bogies.

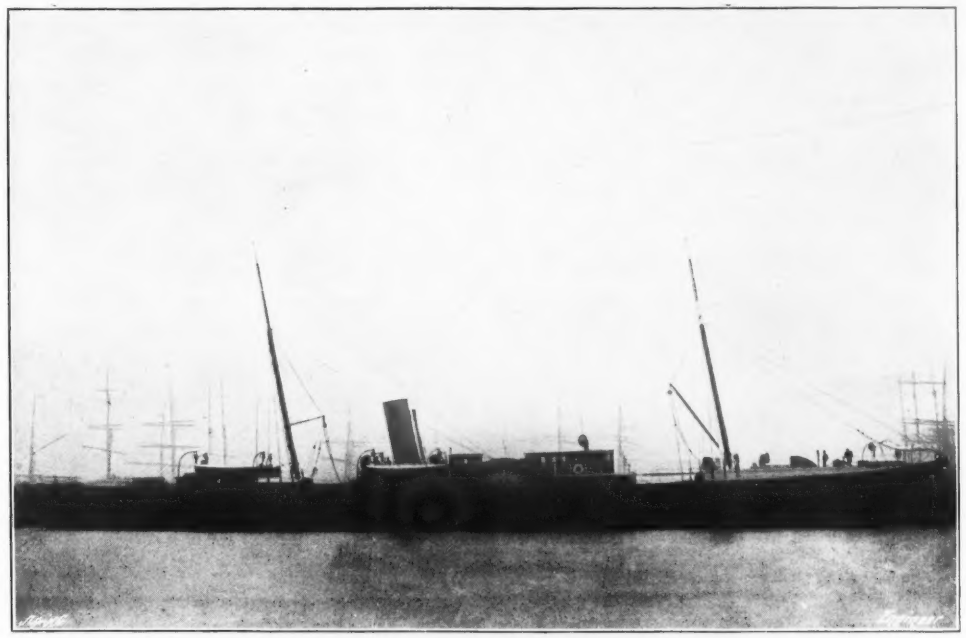
Coming now to the actual erection of the gantry, and the construction of the berths, this was a work requiring considerable skill. The ground is not good—it is anything but good—consisting, as it does, very largely, if not entirely, of silt for a considerable depth. This necessitated the use of piles throughout. The bases of the towers where they come at the present level of the concrete floor are about 21ft. by 9ft., and where they rest on their foundations these dimensions are exceeded. Sixteen piles, some 40ft. long, had to be driven gantry which, though not approaching that which we have just described in either size or capacity, is still in many respects remarkable, and has done and is doing excellent work. It was supplied by the Brown Hoist Company. In construction it is entirely different from the larger gantry. It is arranged between the two berths, and it is carried on a bed composed of concrete placed over a number of piles, for the ground on this side of the yard was no better than that on the other side. There is one single row of uprights 600ft. long and of varying heights from ground level. These are 60ft. apart, and are carried in pin joints. They are made up of plates, angles, and channels. The uprights are composed of two members joined together by four horizontal lattice girders. The upper four of the square spaces so formed are braced diagonally with screwed tie rods and adjusters. The lowest space is braced with two channel and lattice girders, arranged in the form of an inverted V. At the top of these uprights, and at a height of 125ft., run two continuous lattice girders braced together at intervals. One of these girders is arranged over each line of members of the uprights. On the sides of these, with a bearing on the top and bottom and outside face, work two projecting horizontal jibs with an outreach of about 102ft. from the centre of the uprights. These jibs cannot revolve, but they can run backwards and forward and are provided with electrically-worked gantries, which can run from end to end of them. Running on rails free to take place in either direction longitudinally. The top of the girders is reached by an inclined stairway. Lines of narrow-gauge railway are run between the members of the uprights and on each side of them.

Slips Nos. 7, 8, and 9 have not got the same erecting facilities, nevertheless they have their own special equipment. Slip No. 7, for example, is provided with five steel pillar revolving hydraulic jib cranes, two on one side and three on the other. These cranes have an outreach sufficient to place a load in the centre of the slip. The same system is applied to slips 8 and 9. There are also tram lines laid throughout alongside the slips. Use is also made of electric winches, working on the worm and worm wheel system. On this side of the works there are also two jetties and a quay, where fitting out after the ships are launched is carried out.

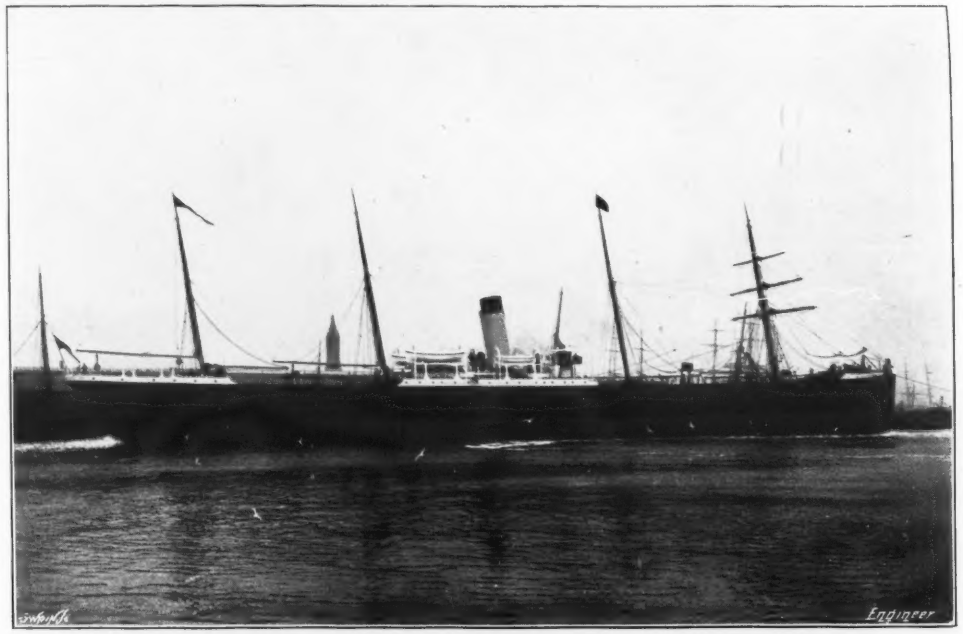
We must next turn our attention to the engineering portion of the works, which is full of interest, and it would be hard indeed to point out any other works which are better arranged or better equipped. A point which struck us forcibly was that the great majority of the tools are of British manufacture, and another thing we noticed specially was the care which had been given to the illumination of the shops.

In referring to the various departments of this part of the works, it will no doubt be best to adhere to the rotation of numbers given in Fig. 1. It will be remembered that Nos. 6 and 7 have first to be referred to. No. 6 does

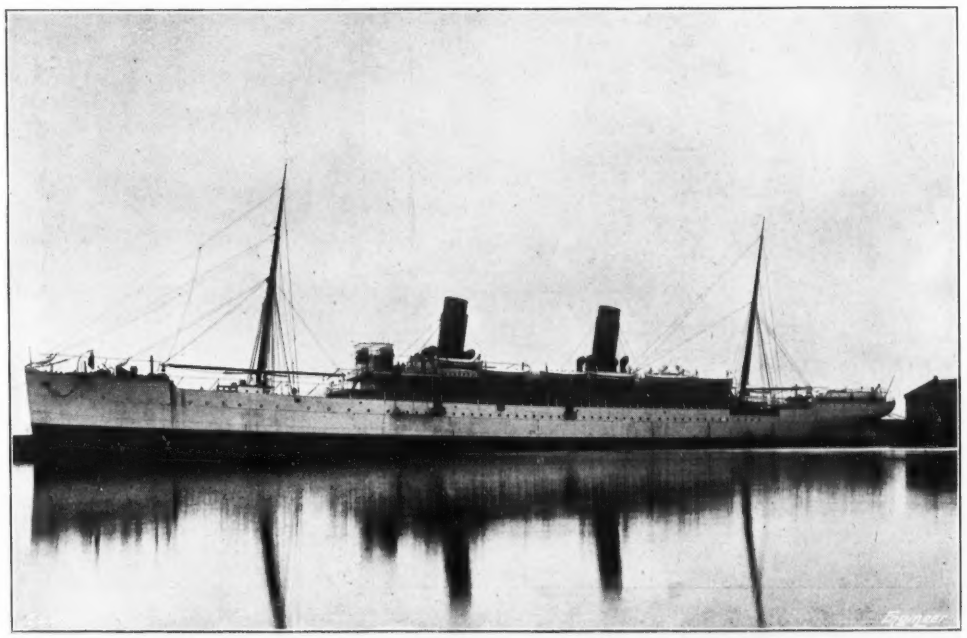
TYPICAL STEAMSHIPS BUILT BY HARLAND AND WOLFF, LIMITED, AT BELFAST



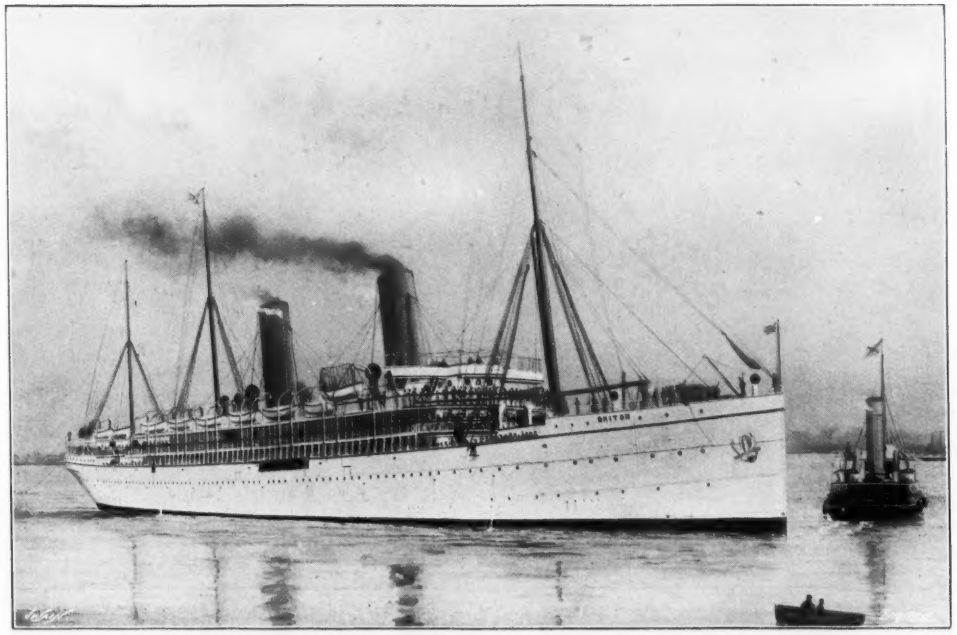
THE PADDLE STEAMER PRINCESS BEATRICE, 1875



THE STEAMSHIP LANCASHIRE, 1889

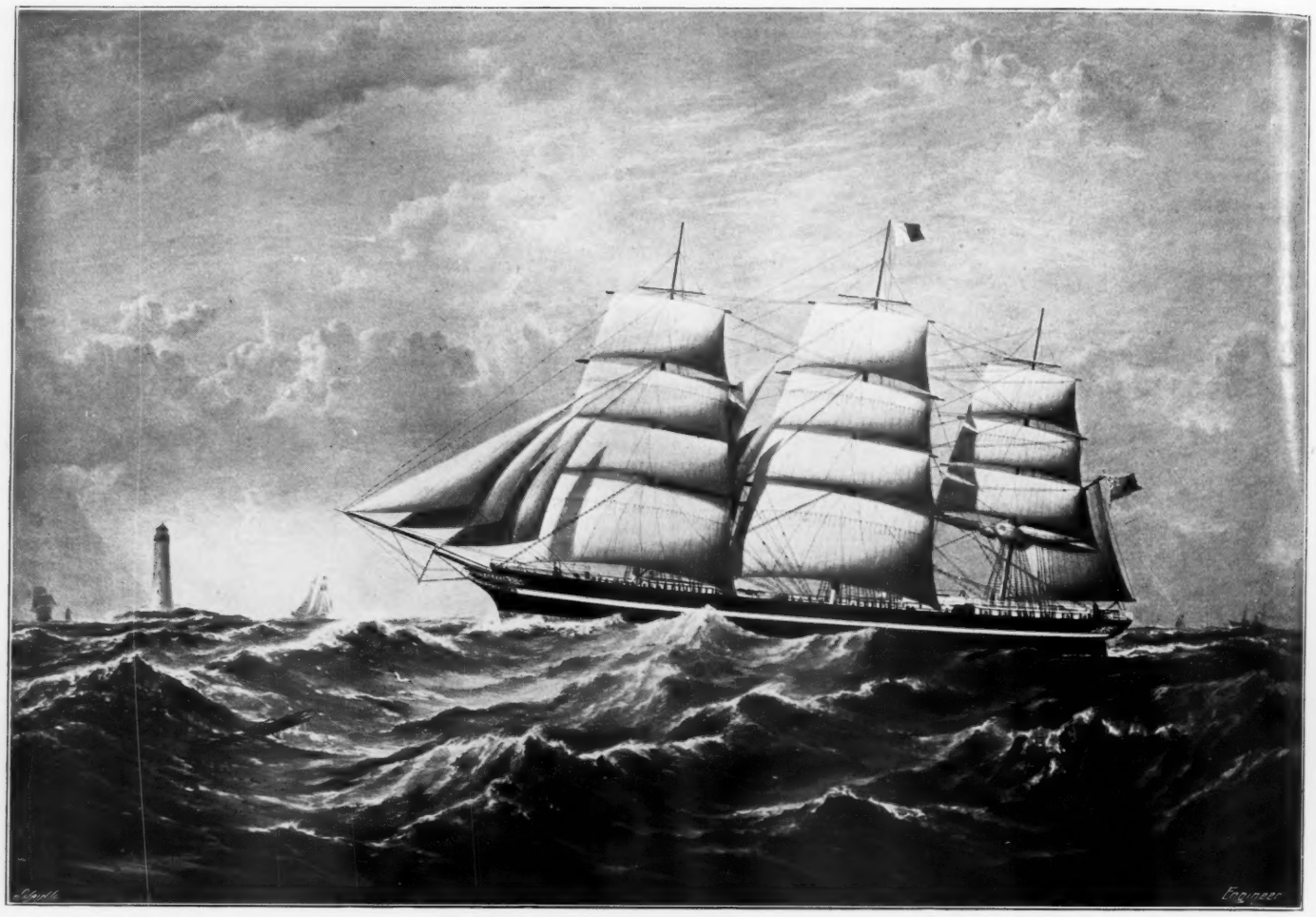


THE UNION-CASTLE LINER NORMAN, 1894



THE UNION-CASTLE LINER BRITON, 1897

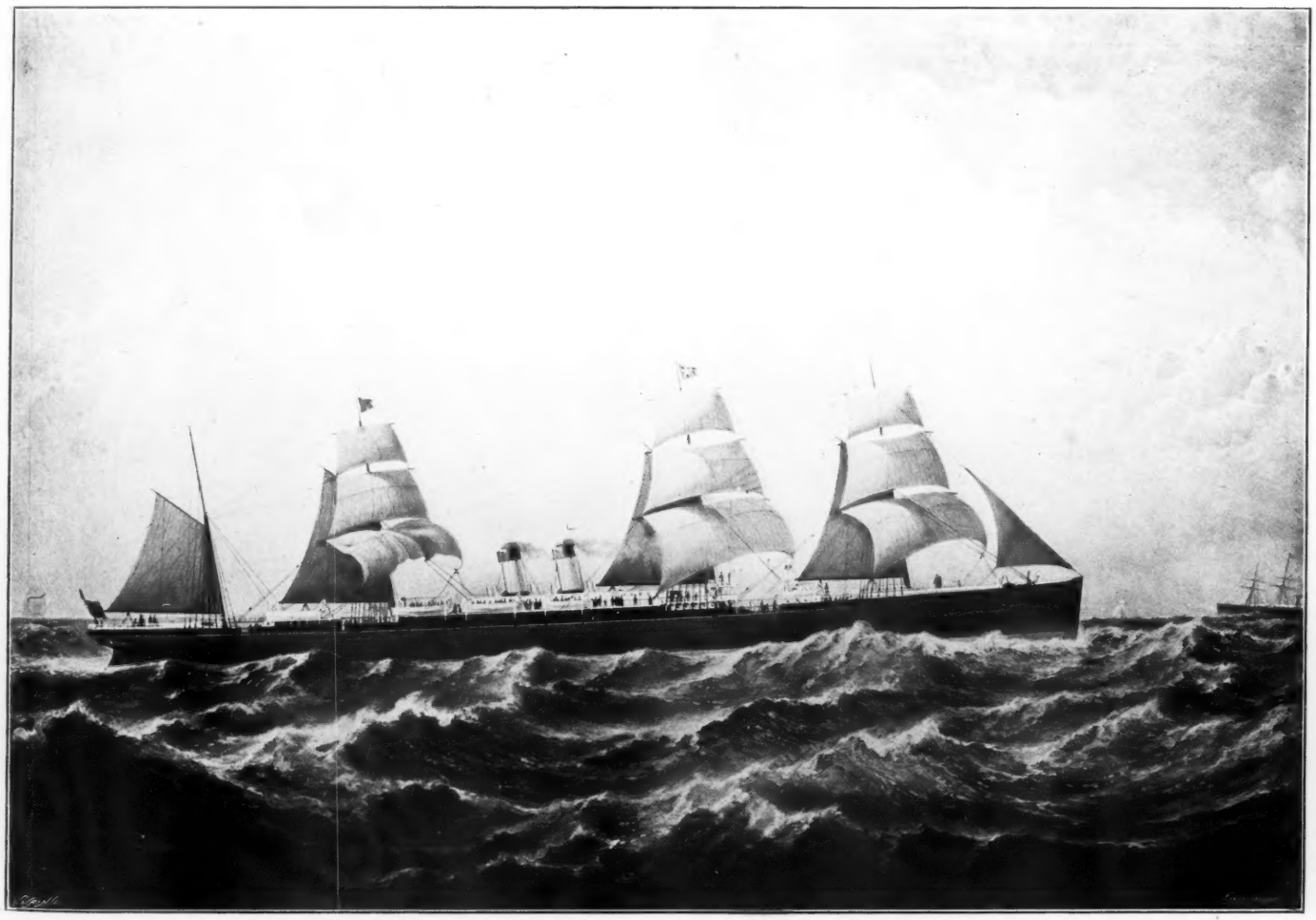
SOME HISTORICAL VESSELS BUILT HA



THE BROCKLEBANK LINE CLIPPER SHIP BARODA, 1864

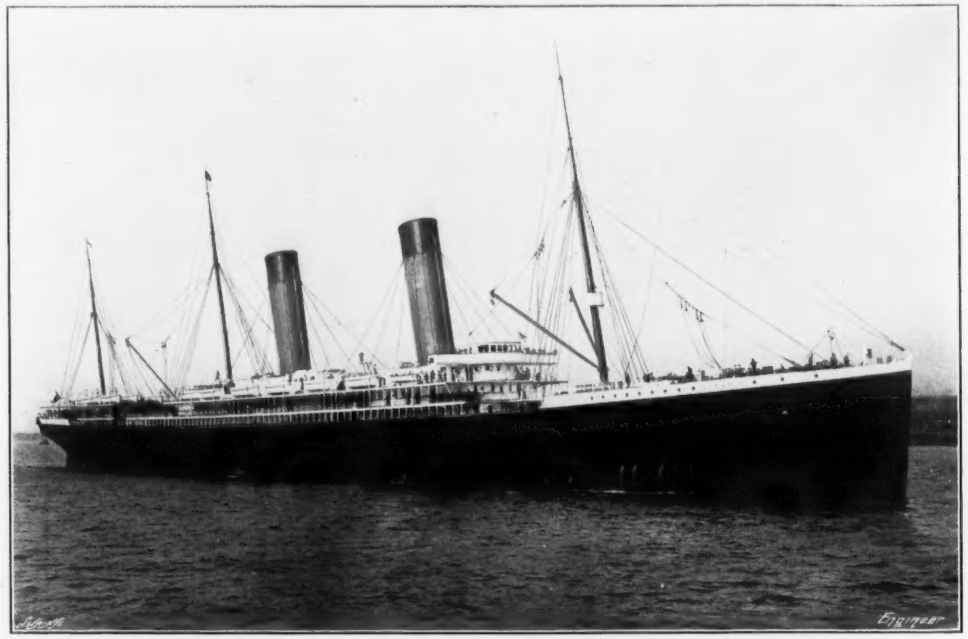
THE WHITE STAR LINER OCEANIC, 1872

THE BIBBY LINER ISTRIAN, 1867

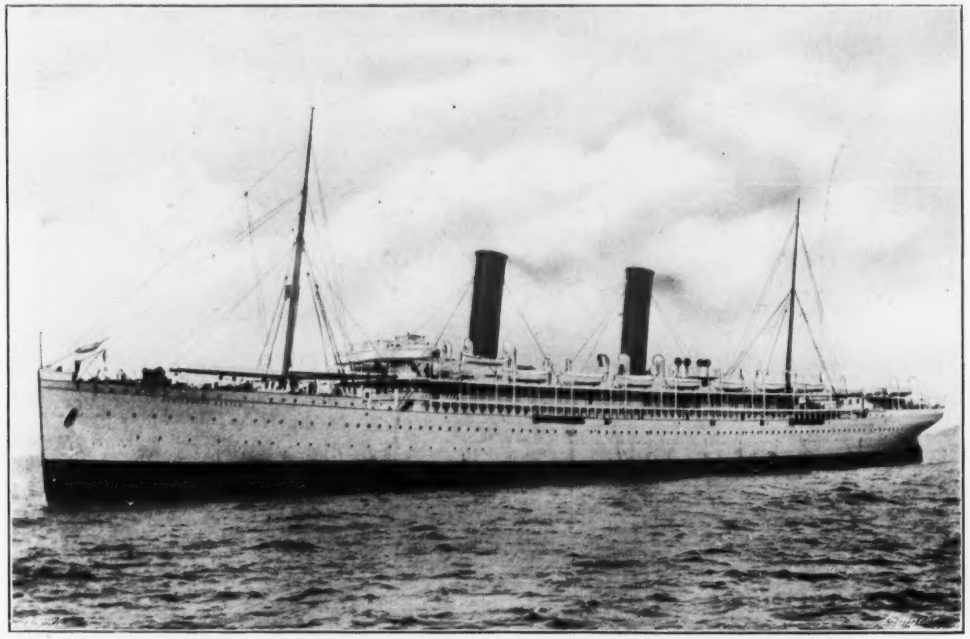


THE WHITE STAR LINER BRITANNIC, 1874

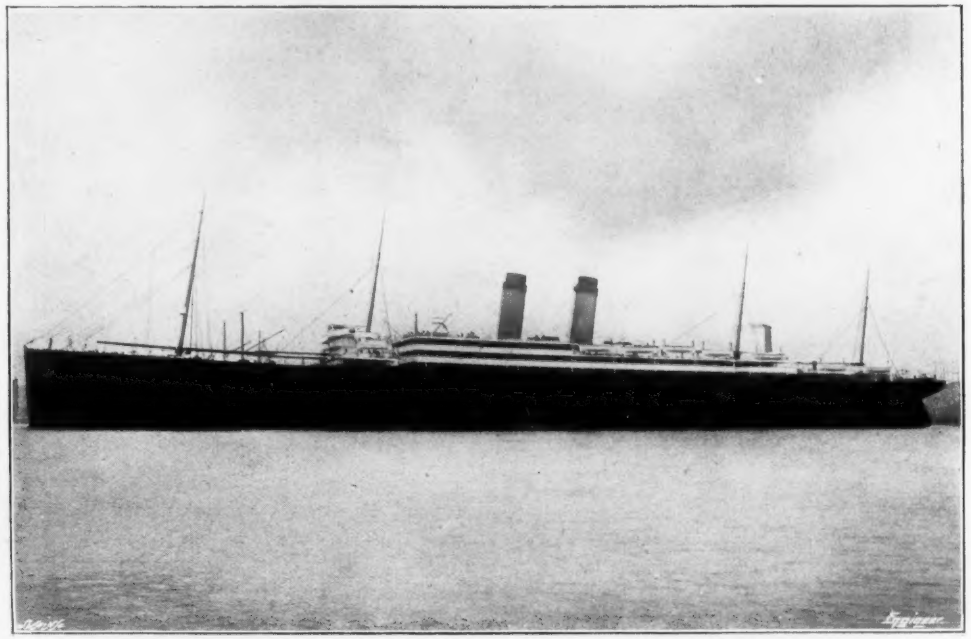
SOME WELL-KNOWN LINERS BUILT BY HARLAND AND WOLFF, LIMITED, AT BELFAST



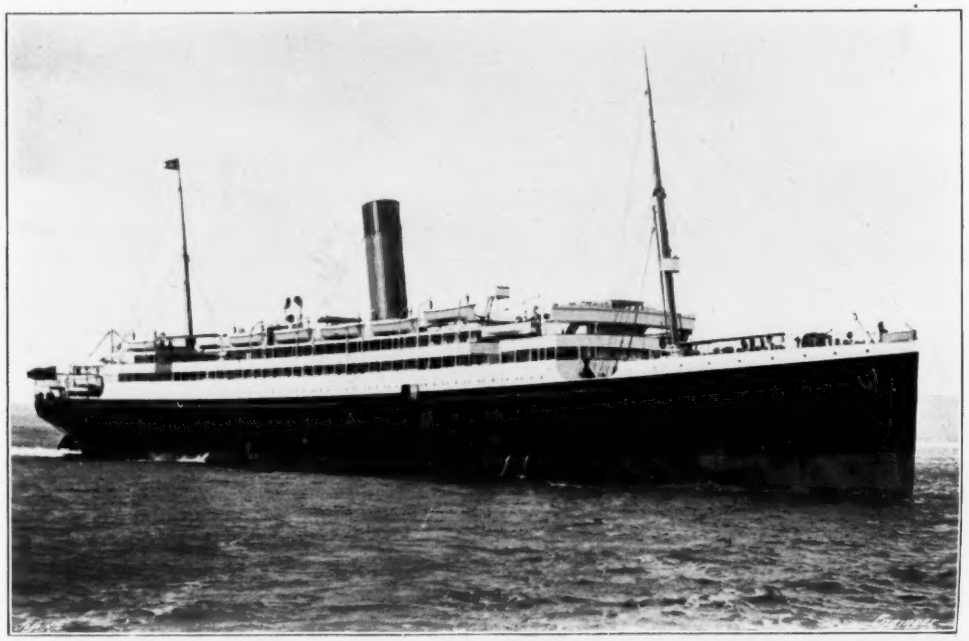
THE WHITE STAR LINER OCEANIC, 1899



THE UNION-CASTLE LINER KENILWORTH CASTLE, 1904



THE WHITE STAR LINER BALTIC, 1904



THE CANADIAN SERVICE WHITE STAR LINER LAURENTIC, 1909

Fig. 12—HYDRAULIC RIVETING SHOP

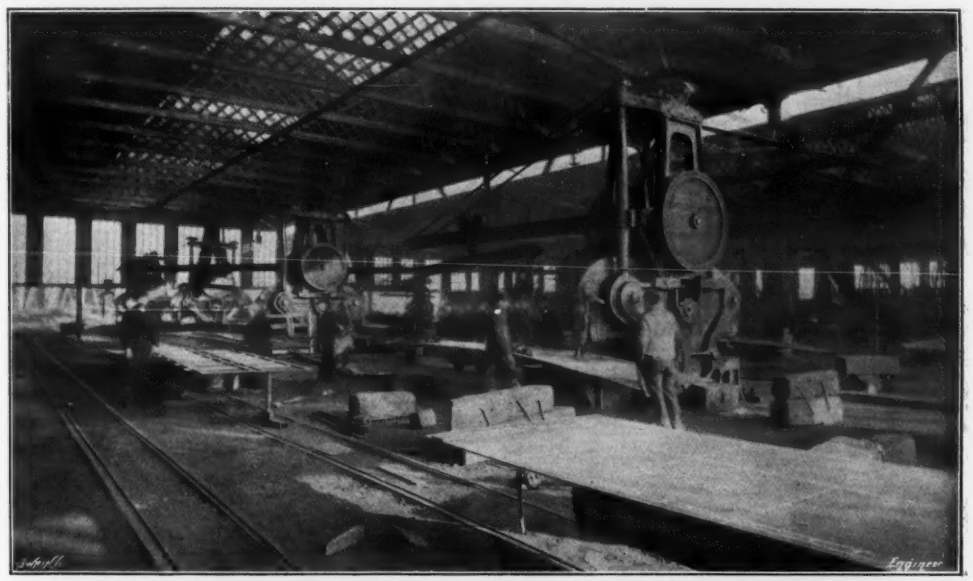


Fig. 13—INTERIOR OF NORTH PLATERS' SHED

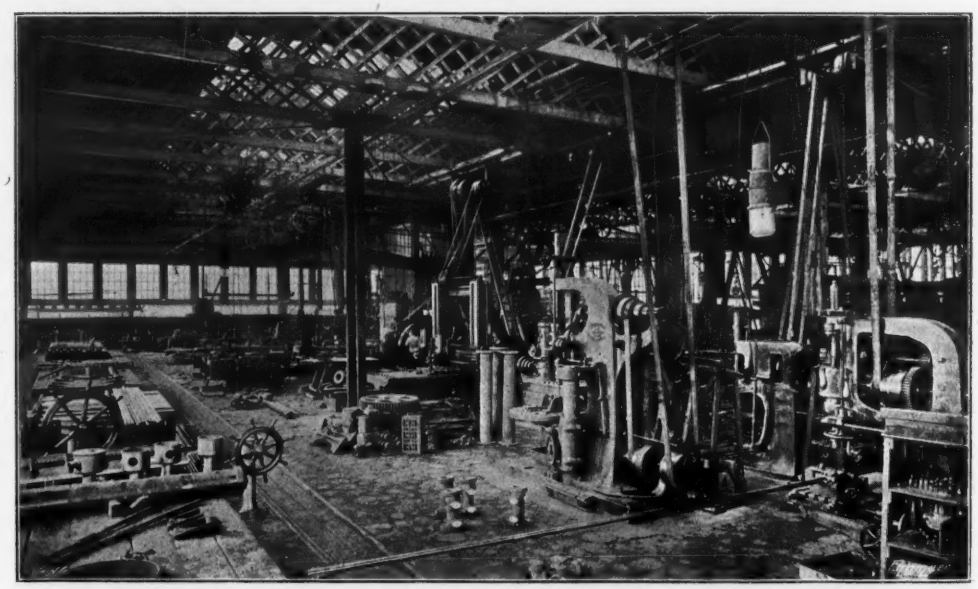


Fig. 14—SHIPYARD FITTING SHOP

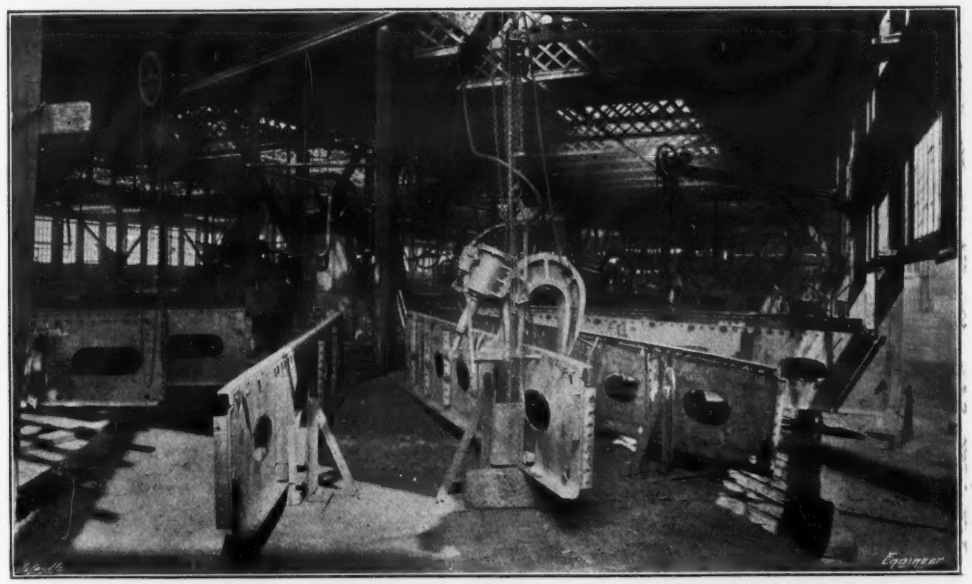


Fig. 15—PNEUMATIC RIVETING SHOP

not call for much comment. It is the shop where all the paints are stored and mixed, and beyond the fact that it is large, has nothing else remarkable about it. No. 7 is a small fitting shop—provided with an equipment of electrically-driven machine tools—in which various odds and ends of work necessary in different parts of the establishment—especially in the power-house, to be hereafter mentioned—are carried out. Neither Nos. 18 nor 19 need be more than mentioned, the former being the foreman's dining hall and the latter the apartment set aside for Admiralty and other Inspectors.

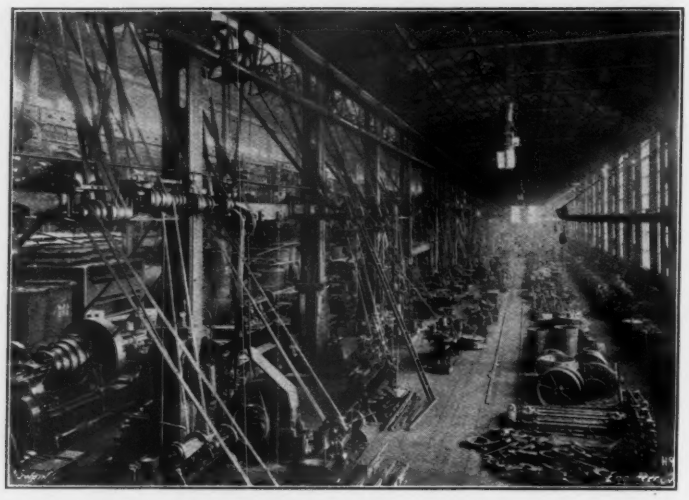


Fig. 16—BRASS FINISHING AND LIGHT MACHINE SHOP

Fig. 17—BRASS FINISHING AND LIGHT MACHINE SHOP

In No. 20, however, the works proper are entered upon. It is the brass-finishing shop—Figs. 16 and 17. Here every sort of brass article required in shipbuilding and engine work is machined and finished. Just a few of the articles produced may be referred to:—Stop valves, portholes, cocks, studs, handles, bolts, nuts, hydrants, relief valves, windows, oil boxes, gauges, screws, general fittings, &c. The machinery employed mostly consists of lathes, capstan machines, repetition tools of various kinds, milling machines, and drills. In common with the whole of the rest of the works, the machinery is electrically driven, and the smaller tools in this shop are mostly run on the multiple system off counter shafting, the motors being mounted high up out of the way. In addition to the work already mentioned, a considerable amount of small copper and brass piping work is done here, four smiths' fires being provided for the purpose. Such piping as requires testing by pressure may here be attended to, hand hydraulic pumps being provided for the purpose. A part of the shop is also allotted to the manufacture of cast iron valve cases, large steel nuts, &c. All the turnings, &c., collected in this shop are passed through a magnetic separator to divide the brass from the iron and steel.

No. 21—see Fig. 24—is called the turning shop, and in it indeed all kinds of turning is carried out, though there is a number of planing machines. Two by Hulse specially caught our attention; they are fine machines, and are fitted with automatic gear to reverse the direction of the motor driving them, each, of course, having its own motor, and this remark may be applied practically to all the larger tools. Another tool which may be specially mentioned is a fine lathe by Shanks. This at the time of our visit was being used for turning up the thrust rings on a shaft. It was being driven by a 30 horse-power motor by Vickers, Sons and Maxim. Another lathe worthy of note had a very long bed-plate and was double-ended. A 15 horse-power motor was driving each end, one of which was engaged in boring a hydraulic cylinder and the other turning a connecting-rod. This tool had been supplied by Smith, Beacock and Tannett. It would, of course, be quite impossible specially to refer to all the fine tools in this shop, but mention should certainly be made of a large vertical cylinder boring machine by Shanks. This is capable of boring cylinders up to 115in. in diameter. It may be mentioned that it is the custom of Messrs. Harland and Wolff to bore all the cylinders of their marine engines—that is to say, those over a certain diameter—vertically. This shop is served by two powerful overhead electrically-worked cranes.

No. 22 is the engine erecting shop, and two views in it are given in Figs. 25 and 26. Here are the erecting pits, in which the sets of marine engines are erected. On the occasion of our recent visits there were two fine sets of quadruple-expansion engines for an Atlantic transport liner nearly finished. There is a very excellent collection of tools in this shop. They are all good in design and execution, and almost without exception they are of British manufacture. For the most part they are large tools for dealing with heavy work, as might be expected, as all the heavier machining before erection is done in this shop; but there is, of course, a good sprinkling of lighter tools. For instance, there is a certain number of capstan head and repetition machines, as also of small lathes and drilling machines, amongst the latter being several fine tools by Asquiths, of Halifax. If there is one special feature more than other, it is the extended use of the slotting machine. This tool is present in all forms and sizes. There are several of the planing machines which are worthy of special mention, notably one by Smith, Beacock, and Tannett, and not a few by Shanks. Of the horizontal planing machines we may refer specially to one by Bucktons. Noticeable among the larger lathes is a fine example of shaft lathe. At the time of our visit this machine was dealing with a shaft 23ft. 4½in. long and 14½in. in diameter in the rough. It was being driven by a Laurence Scott motor of 40 horse-power. There were numerous examples of boring machines, among these being a battery of five tools at the cross shop at the end marked K, Fig. 1. Another large tool of this kind was being used for machining crossheads. Mention may also be made of a powerful face-plate lathe with a face plate some 14ft. in diameter, this tool being made by Shanks. It was dealing with a large crank shaft at the time of our visit. The boring mill is perhaps not quite so much in evidence as in other engineering works, but it is not absent by any means, and we may mention one with a 6ft. table and a 7½ horse-power motor and two tool heads as being an excellent example of this type of tool. We must certainly not forget to mention a very fine Norton grinder which is capable of taking in work up to 18ft. in length. As might be expected, the arrangements for moving and lifting weights in this shop are on a generous scale. In its main bay, which runs parallel to shops 21 and 23, there are three overhead electric travelling cranes of varying powers, the largest of these being capable of lifting 30 tons. There is also a further overhead crane which can travel the full length of the annexe K. In addition to these facilities standard and narrow-gauge lines are laid throughout the shop, and a steam travelling jib crane runs on the former, and can bring heavy weights into the shop, or take them out to load them on to lorries or trucks in the Abercorn-road. In the annexe K there is a number of fitters' benches, and in this bay such work as the planing of cranks and the turning of shafts and connecting-rods is done; also a certain amount of shaping work, such as that of large cranks, and the boring of these. The machining of excentric sheaves, gear wheels, &c., is also carried out in this part of the shop, as well as the fitting together of stop valves, and the boring and slotting of small cylinders.

Fig. 18—BRASS FOUNDRY

Fig. 19—SMITHS' SHOP

No. 23 is the engine fitting shop, Fig. 27, and here a large variety of work is carried out. The tools are not quite so heavy as those in shop 22, but they are none the less fine tools. We noticed that the work went from the sides to the middle of the shop as it got nearer and nearer towards completion, rather than from end to end, as is the case in some works. There, is, however, a regular system employed throughout, which has for its object the reduction of the handling of the material to a minimum. In this shop there is a well equipped tool room, in which all the tools used in shops 20, 21, 22, and 23 are made and kept in order, as well as all the necessary gauges, &c. The special tools include grinders of various kinds by Sellers, Muir, &c., a small pneumatic hammer for the rapid shaping of the tools, lathes, milling machines for forming milling cutters, &c., as well as a smiths' fire, and a small heating and annealing furnace. The whole room struck us as being particularly well arranged and managed. The main tool equipment of shop 23 comprises milling machines, planers, drills and lathes, though there are, of course, some other tools. Amongst the very large variety of work carried out here, we may mention first of all the preparation of the white metal bearings for large engines. The white metal in these, after being run, is carefully consolidated by being struck all over with a round-ended hammer before being bored. The worm and worm wheel cutting machines are also of interest. Here, too, is carried out the hydraulic testing of cylinders and such like. The shop contains a large

number of jib cranes, and is served by two overhead travellers each of 10 tons capacity.

A word or two may well be added concerning the buildings, which contain these shops—Nos. 20, 21, 22 and 23. Generally speaking—and this remark applies to practically all the buildings in the works—the structures, while being amply strong and serviceable, are not expensive in their design. The walls are formed of cast iron uprights, covered partly with corrugated iron and partly with wood, where the windows do not come; but as the number of windows is very numerous, the amount of wall space that is so covered is by no means great. The illumination of all the shops is excellent both by day and by night, a plentiful equipment of arc and incandescent electric lights being provided for work during the hours of darkness. The cast iron uprights already mentioned also carry the roof principals. Some of these are made of light iron sections, but the majority are of wood, having the form of a bow, the space between the string—in this case a wood beam—and the bow being filled in with wood lattice work. This type of roof principal is largely met with in the works and is, we understand, actually known as the "Belfast" roof. Sometimes they are covered by corrugated iron, and sometimes with wood or slate. In the particular case of the shops under discussion both types of covering are employed.

twenty-six is driven by a three-phase Allgemeine motor of 20 horse-power, which runs at 1650 revolutions per minute. There are several heating furnaces, and various radial jib cranes. We particularly noticed also a large shearing machine by Craig and Donald, driven by its own motor. The lighting of this shop for night work is by means of arc lamps.

Building No. 25 contains the pattern shop and the pattern store. Each pattern is given its own special number, and a place is allotted to it in the stores, a careful register being kept. The pattern store and shops are in the same building, which is handy in case alterations are required. It will be noticed that it stands apart by itself. It has cast iron uprights, corrugated iron sides, and a wood roof. The pattern store is divided into two bays, and it has been necessary to provide a gallery to help store the patterns. The pattern shop is in one bay, and is light and airy. It is equipped with circular saws, planers, band saws, emery wheels, grindstones, lathes, &c. Here, again, some of the tools have their own motors, and some are bunched and driven off a countershaft. Suction arrangements are provided for withdrawing the sawdust from the machines. The shop is lit with arc lamps. A view of it is given in Fig. 21.

Building No. 26 is a general store and calls for no comment, saving that it is exceedingly well arranged.

pillar jib cranes which can each lift and swing a load of 3 tons, besides other smaller cranes, including fixed jib hand cranes provided with monkeys. This foundry is exceedingly well organised, and it turns out some really beautiful castings. It has a moulding space of some 85,000 square feet. We were informed that single castings up to 60 tons in weight can be dealt with. In A there are two coke ovens, in B three, and in D two, all of them being large. The roof of A is made of wood lattice girders, but those of B, C, and D are made of light iron sections, the walls in each instance being of cast iron uprights generally covered with corrugated iron. A good deal of attention has been paid to the illumination, these shops not by any means being the dark gloomy places that one so often finds foundries to be.

The fettling shop, No. 27, is a long building constructed in the same manner as the other buildings previously described. Narrow and wide-gauge railways are laid throughout its length, which connect by means of turntables with lines running into other shops. There is an overhead crane running along it which is meant for lifting light castings, its capacity being 5 tons. In this shop not only is a great deal of the fettling done, but some moulding is also carried out, particularly for such of the smaller articles as lend themselves to mechanical moulding. We noticed a number of Tabor moulding

Fig. 20—THE FORGE

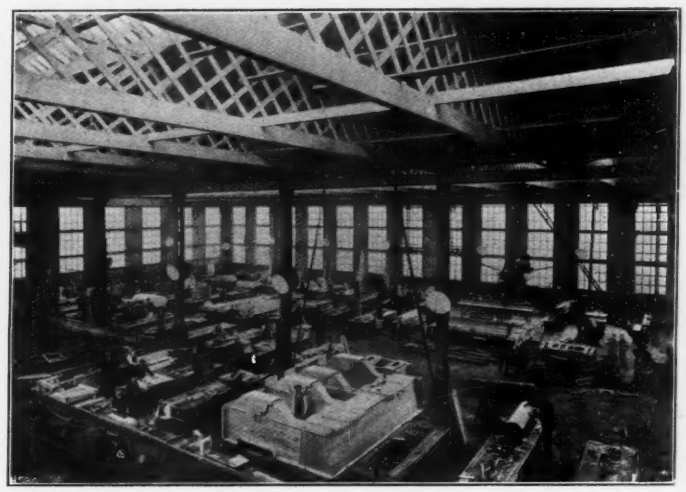


Fig. 21—ENGINE PATTERN SHOP

Fig. 22—THE FETTLING SHOP

Fig. 23—IRON FOUNDRY FROM THE NORTH END

The next shop in regular order is No. 24. It is the Forge. A view in it is given in Fig. 20. It is divided into two bays placed at right angles to one another, and for convenience sake we will designate them X and Y, as shown in Fig. 1, page i. Here, again, the same sort of general construction of building has been employed, but in the case of X light iron principals and corrugated iron roofing have been used, whereas in Y there are wood lattice principals and roof. The sides are of wood throughout. Narrow-gauge lines coming in from the yard traverse the shop in all directions. In X there are in all eighteen smiths' fires, and the blast for these is provided by a Sturtevant No. 6 blower, driven by an Allgemeine Elektricitäts Gesellschaft motor. The equipment also includes two Pilkington pneumatic hammers and a small heating furnace. In Y there is somewhat of a curiosity. It is the only steam hammer in the works. It is there with its boiler close by, but it is not to be worked by steam much longer. Indeed, by the time these lines are in print it may have already been converted for use by compressed air—the medium employed for all the other hammers in the works—and its boiler diverted to other uses. This hammer is one of six in this portion of the shop, the remaining five all being made by Pilkington, and all being worked by means of compressed air. There are no less than twenty-six smiths' fires—making a total of forty-four such fires in the two bays of this shop. The blower for providing the blast for these

It will be convenient to take shops Nos. 27 and 29 together. They are the fettling shop and the foundry respectively—see Figs. 22 and 23. The foundry is an irregularly shaped building divided into four main divisions. It is served by four cupolas having a combined capacity of 30 tons per hour. Pig iron, scrap, and flux are taken up to the level of the charging platform by means of an electrically-worked lift, the cupolas being arranged in a group, so that they can all be charged from the same platform. The blower which provides the blast was made by the Baker-street Foundry and Engineering Company, Limited, of Sheffield, and it is driven by a 25 brake horse-power motor working at 450 volts and 630 revolutions per minute, and supplied by W. H. Allen, Son and Co., Limited, of Bedford. Running on standard gauge lines which come in from the yard is a powerful travelling steam jib crane made by J. H. Wilson and Co., Limited, of Liverpool. By means of this materials can be not only moved about from place to place, but may be brought into and taken out of the building, standard gauge lines being laid throughout. This is not, of course, the only means of transport, for the shop is exceptionally well provided with overhead cranes. For example, in the part marked A there are two powerful overhead travelling cranes capable of dealing with 30 and 10 tons respectively. In the part B there are likewise two overhead cranes, and their powers are 40 and 30 tons, while in D there is one overhead crane of 40 tons and three fixed

machines of various sizes, and also a mechanically-worked jigger sieve. There are two smiths' hearths, the blast for which is supplied by a blower electrically driven by means of a motor through a belt. Pneumatic tools are largely used, and as a stand-by for use when for any reason the main compressors are not at work there is a stand-by compressor made by Hartley, of Manchester, which is driven through gearing and belting by a 12 horse-power Allgemeine motor. The artificial lighting of both the foundry and the fettling shop is by means of arc lamps.

We have next to turn our attention to No. 28, the brass foundry—see Fig. 18. "Brass" in this case is, of course, a somewhat wide term, including as it does not only brass, but all sorts of bronzes and gun-metals, as well as white metal for bearings, &c. This shop is divided into two bays, and contains two overhead travelling cranes, one for 20 tons and the other for 10 tons. It might be wondered at that cranes of the larger size should be required in a brass foundry, but it should be remembered that propeller blades and other heavy articles of the kind are cast here, and that a propeller blade may weigh with its rising head certainly 9¾ tons, and a G.M. boss 12¾ tons after being cleaned up.

We may perhaps here say a few words regarding these propeller blades, for as finally turned out they certainly represent some most excellent work. They are machined with the very greatest care, and when completed

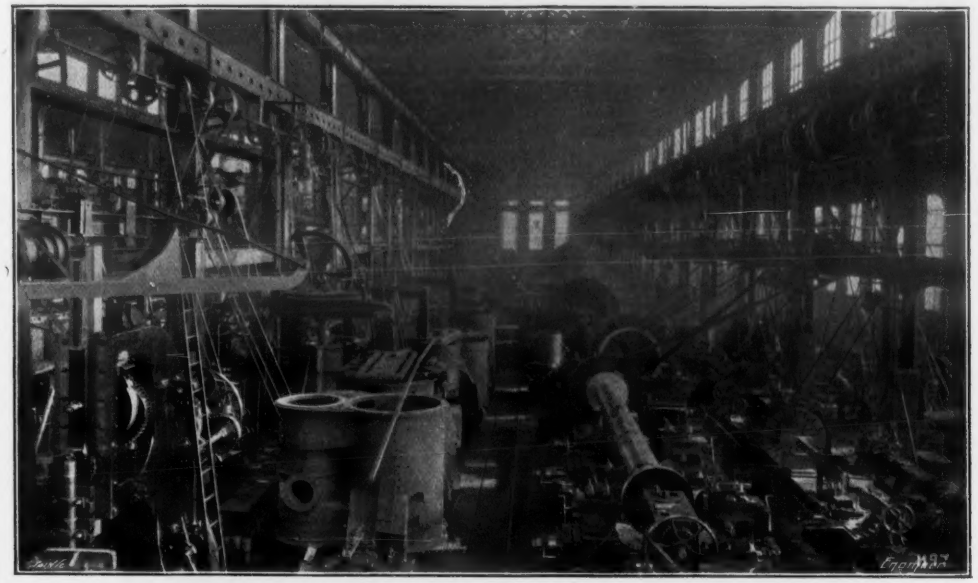


Fig. 24—MAIN TURNING SHOP FROM THE WEST END

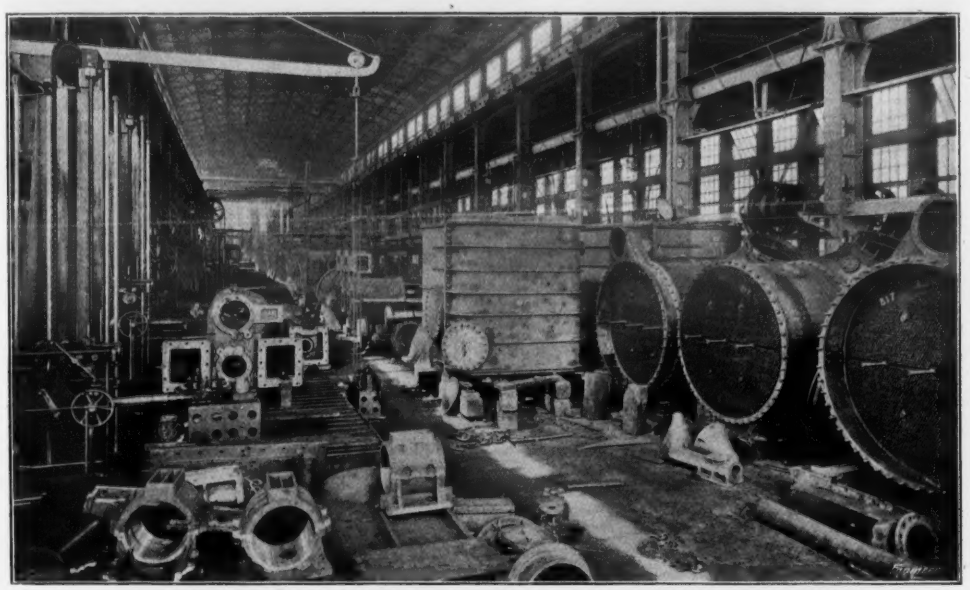


Fig. 25—ERECTING SHOP FROM THE EAST END

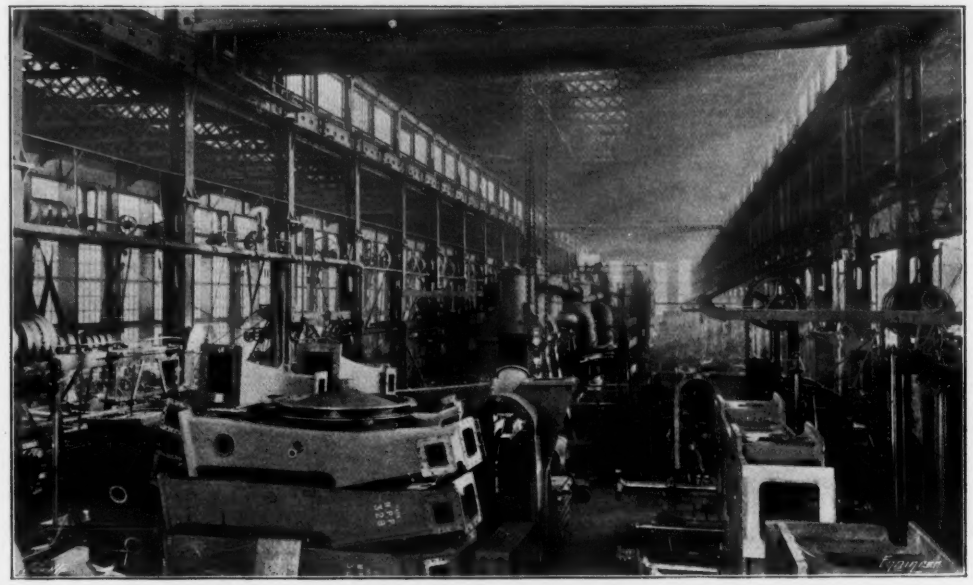


Fig. 26—ERECTING SHOP FROM THE WEST END

Fig. 27—FITTING SHOP FROM THE WEST END

THE BOILER AND FUNNEL DEPARTMENT

Fig. 28—VIEW SHOWING VERTICAL AND HORIZONTAL ROLLS

Fig. 29—THE BOILER SHOP FROM THE SOUTH END

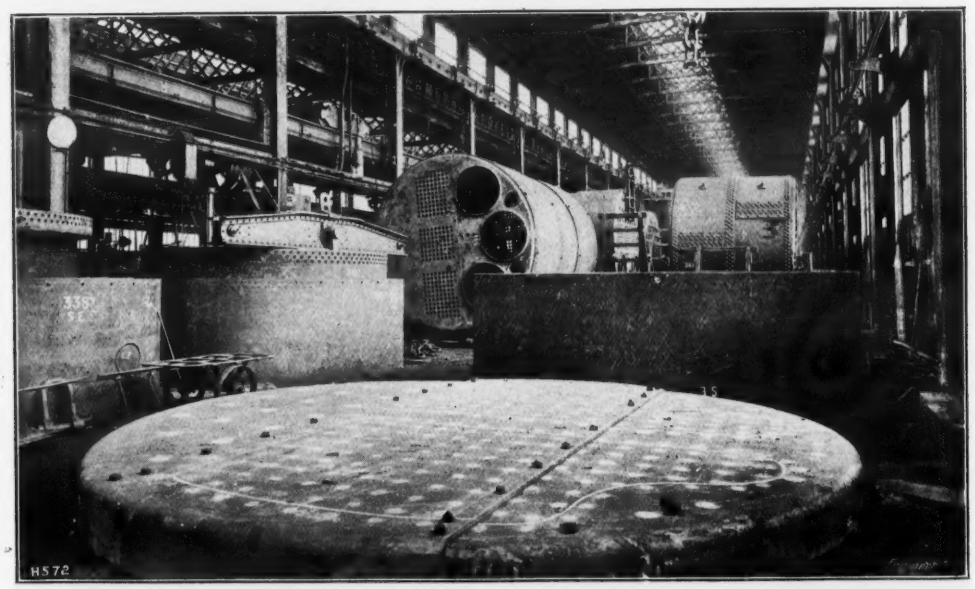


Fig. 30—BOILERS UNDER CONSTRUCTION

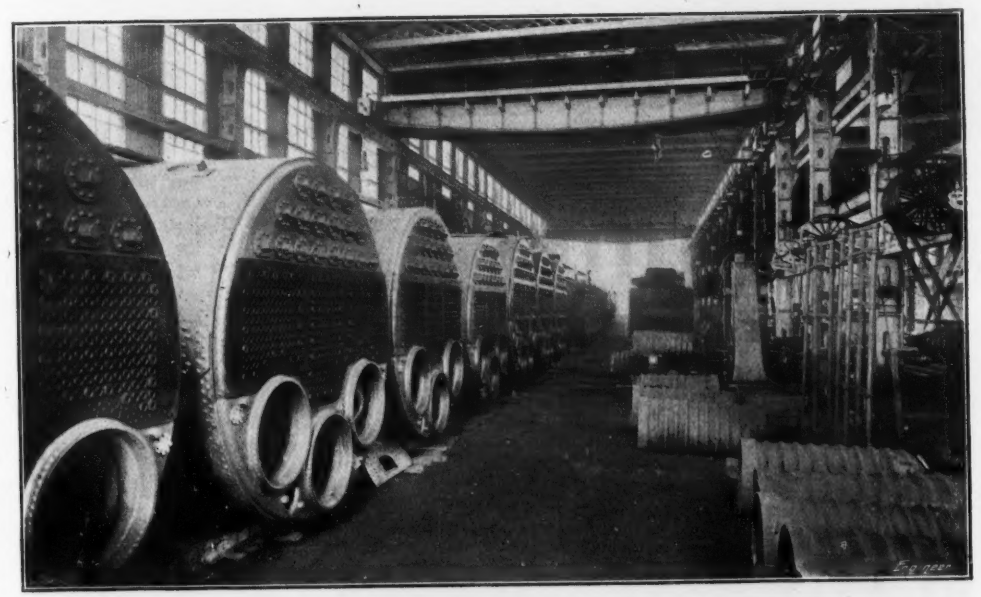


Fig. 31—VIEW SHOWING RANGE OF BOILERS FOR A LARGE ATLANTIC LINER

are almost as finely polished as is a mirror. Moreover, they form excellent examples of good casting. We saw a great many of them passing through the shops, and in no case did we see any blowhole—and this in spite of their great weight and size. Of course, heavy rising heads are used, these weighing in some cases as much as 1¾ tons.

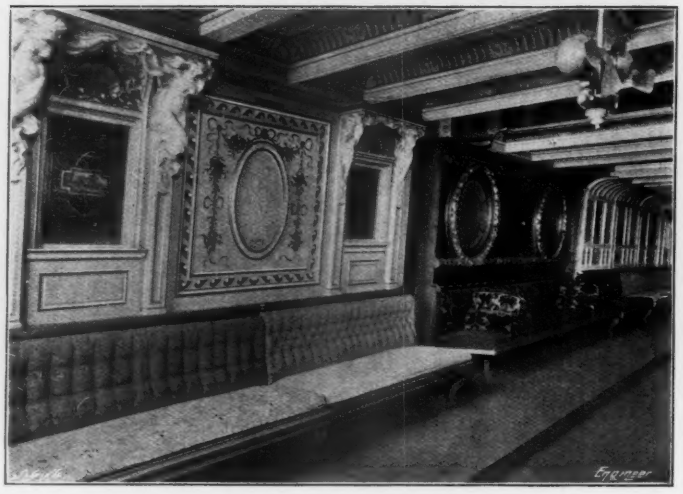


Fig. 32—ONE OF THE SAMPLE ROOMS

Fig. 33—THE SAW MILL

For melting the various metals there are pot and reverberatory furnaces of various kinds, as well as a white metal melting furnace. Tabor moulders are largely used in this shop, the equipment of which is completed by several core ovens. Narrow and broad gauge lines come into the shop from the yard. The artificial illumination is by arc lamps.

We now come to what is one of the most important shops in the whole works—the Boiler shop—marked 30 on Fig. 1. Four views in it are given in Figs. 28, 29, 30, and 31, on page ix. A great variety of work is carried out in it in addition to actual boiler making. As an example we may quote the huge funnels for liners, which now-a-days attain such enormous dimensions. Perhaps our best plan in order to give some sort of an idea as to the equipment of this fine shop will be to mention a few of the tools which may be noticed in a walk through the shop. It will be seen on consulting the plan—Fig. 1—that the shop is divided into two main parts, which are at right angles to one another. On entering at the end of the shop opposite to the gate house, No. 32, one's eye is caught at once by a fine right-angled plate edge planing machine by Hetheringtons, which will take in plates up to 36ft. long. Two 20 horse-power 440-volt Vickers motors are geared to this machine. They are constructed to run at speeds varying from 300 to 900 revolutions per minute, and are governed by an automatic controlling gear which reverses the direction of the tool when it comes to the end of the cut. Close by is a large vertical boring and surfacing machine by Embleton and Co., of Leeds. This also has its own motor. Then there is a tube-plate cutting machine by Shanks, and a smaller plate edge planer by Bucktons. This also is automatic in its action, and, like the other, has a variation in speed of from 300 to 900 revolutions per minute in its motor, which is of 10 horse-power, and is made by Vickers, Sons and Maxim, Ld.

After passing by a shearing and punching machine, some small plate rolls, a marine boiler tube plate drilling machine, and some other smaller drills, we come to a series of hydraulic machines which are noteworthy. In the first place, there are three fixed hydraulic riveting machines, which can take in work about 5ft., 9ft., and 15ft. deep respectively. The first of these is furnished with its own electrically-driven hydraulic pump and accumulator, but the others are worked off the main system of pressure pipes which are laid throughout the works. Another large and interesting tool is an upright hydraulic plate bending machine which will take in plates up to 12ft. wide. This machine, which was made by Fielding and Platt, of Gloucester, works on the toggle principle, rollers being made to run up inclined planes by means of hydraulic cylinders. As a contrast to this there is, not far away, a large set of horizontal bending rolls made by Shanks, and driven by a 33 horse-power motor running at 270 revolutions per minute. This can take in work up 10ft. 6in. wide. Other tools in this part of the shop include a set of three radial drills by Shanks, each driven by its own motor; two punching and shearing machines by Craig and Donald, both electrically driven, the motor in the case of one being mounted on a spring carriage, and of the other rigidly; some smaller plate bending rolls driven through gearing by a 12 horse-power motor running at 860 revolutions per minute; some small flattening rolls, also driven electrically through gearing by a 7 horse-power motor, the speed of which is 590 revolutions per minute; some further drills, &c.

The two main bays of this portion of the shop are served by six electric cranes—two in one bay, each by Cravens, and each of 5 tons capacity, and four in the

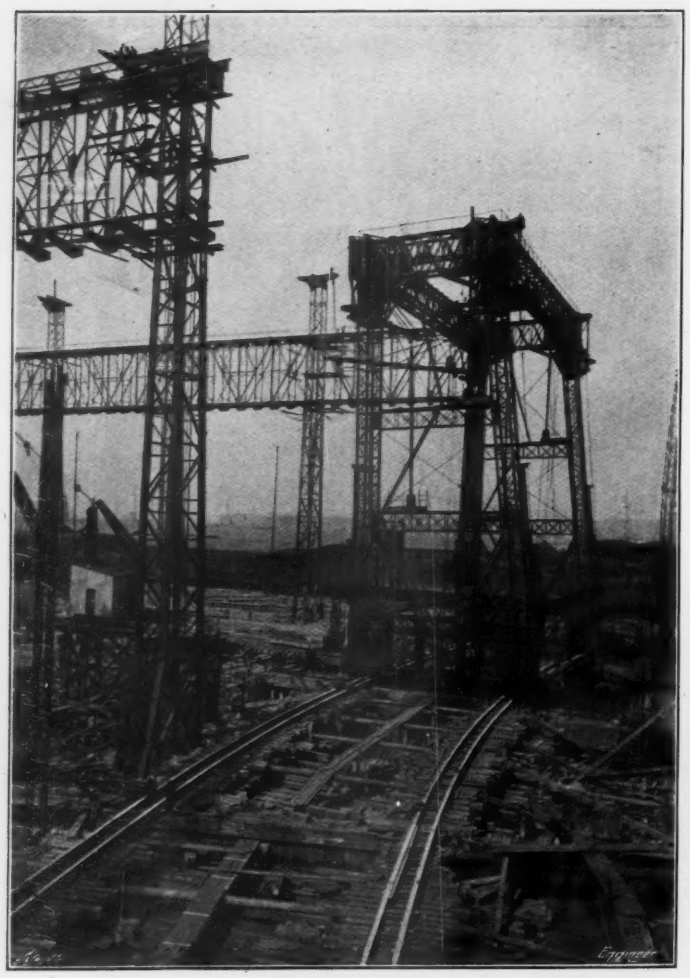


Fig. 34—MOVING GANTRY TO SLIP No. 1

Fig. 35—SPECIAL TRUCK FOR MOVING GANTRY

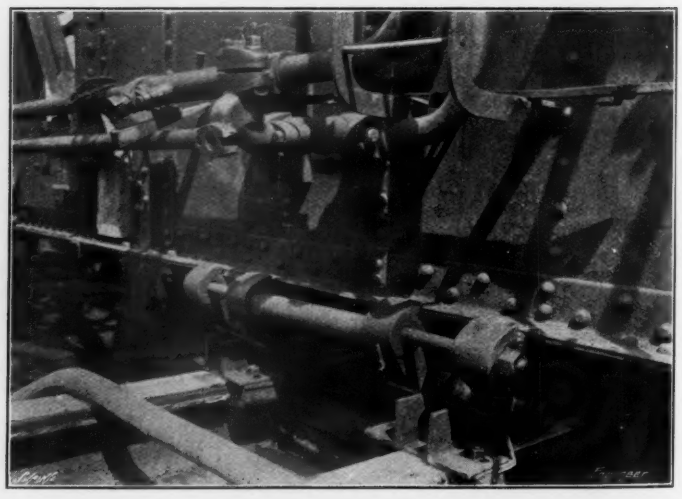


Fig. 36—GANTRY RESTING ON SPECIAL TRUCK

SOME AUXILIARY DEPARTMENTS

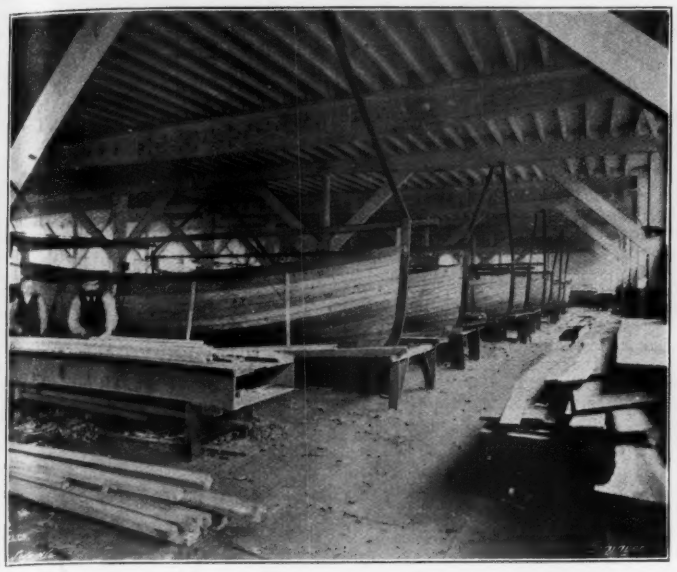


Fig. 37—BOAT-BUILDING SHOP

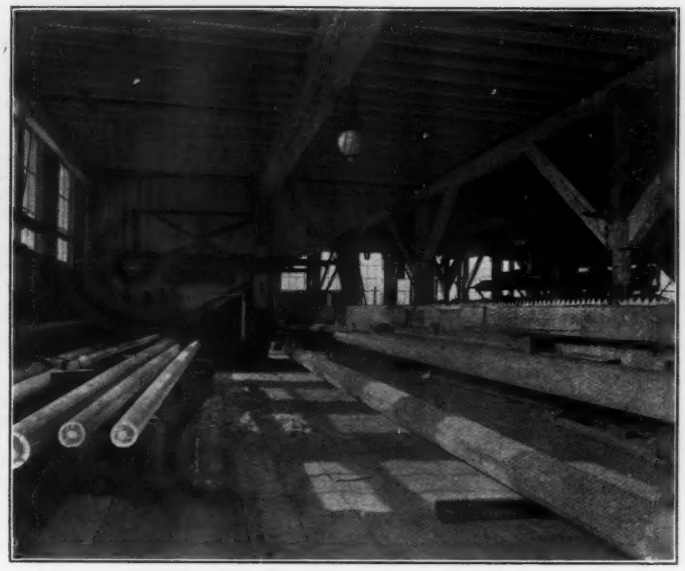


Fig. 38—SPAR-MAKING SHOP

Fig. 39—AWNING AND SAIL-MAKING SHOP

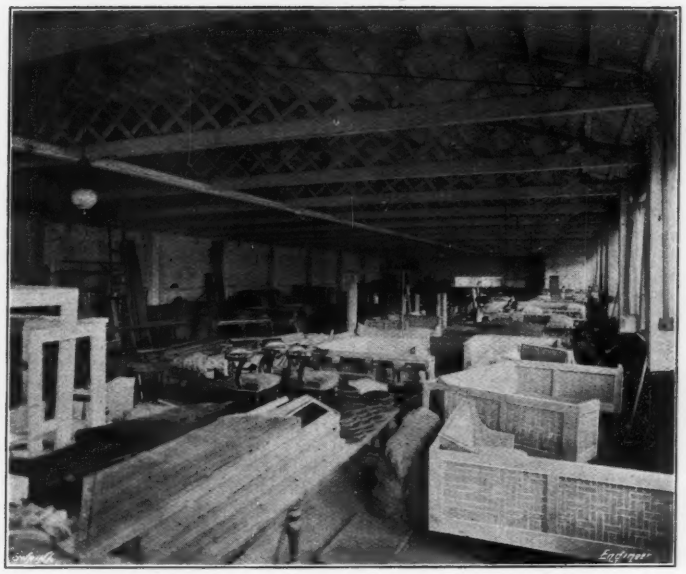


Fig. 40—UPHOLSTERER'S SHOP

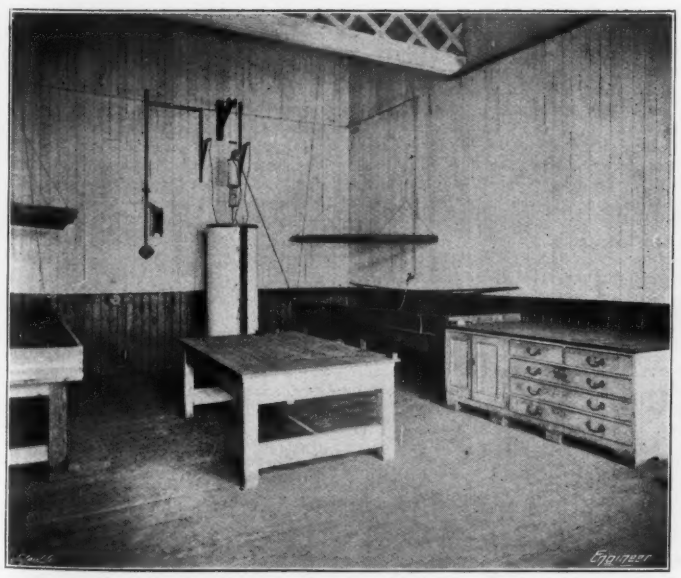


Fig. 41—PHOTO-PRINT AND PHOTOGRAPHIC DEPARTMENT

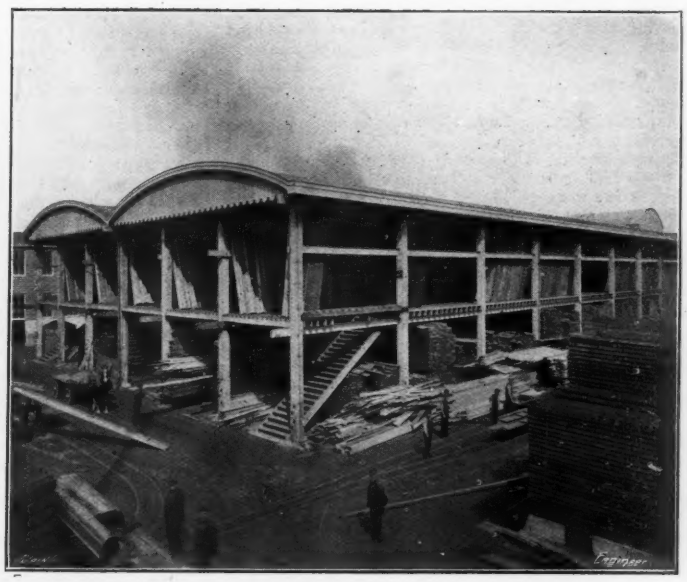


Fig. 42—TIMBER DRYING SHEDS

other bay, these being of varying powers. There are two large plate heating furnaces in one of the smaller bays—marked E on the plan. These have their own separate chimney, and are provided with steam forced draught. There is also a number of rivet furnaces. This bay is provided with a 5-ton overhead crane. In the small bay marked F there are seventeen smiths' hearths, the blast for which is provided by a motor-driven fan. Here, too, is a Nasmyth-type power hammer, pneumatically worked, the makers of this being Davis and Primrose, of Leith. The buildings have cast iron uprights and light section principals, the sides and roofs, where there are no windows or glazing, being of corrugated iron. The shops are exceedingly well lit. Arc lamps provide light for night working. Full gauge rails run into the shop from the yard and roadway.

At right angles to that part of the boiler shop which we have just been describing is the other portion of the shop. This consists of two long bays running side by side. At the end nearest to Queen's-road there are six smiths' hearths, and near by are two electrically-driven punching and shearing machines by Craig and Donald. Each has its own radial jib crane. Next comes an automatic electrically-driven plate edge planing machine by the same makers, the motor for which is of 10 horse-power. It would be wearisome to enumerate the whole list of excellent tools and machines which find a place in this shop, but we may say briefly that among a number of others there are an electrically-driven horizontal air compressor; a special boiler drill, with four adjustable uprights, by Smith, Beacock and Tannett; numerous countershaft by a single motor; another saw driven by its own motor; and a machine for breaking the coke for the smiths' fires. Narrow-gauge tramways run the whole length of the shop, and the artificial lighting is by means of arc lamps.

Buildings 32 and 33 are the gate house and time offices, and nothing very much need be said about them, saving that, like everything else in the works, they are well thought out and arranged.

Passing now to the far end of this large block of buildings, we enter the "storage yard," and the first shop met with is No. 6—the paint shop—to which we have already referred. Next come Nos. 34 and 35, these two being in one building divided into two floors. First of all, there is the spar-making shed—Fig. 38—in which wood masts and spars of all kinds are made. The raw timber is adzed to begin with, in order to get it roughly into shape—and in this operation the men show very considerable skill—and is then smoothed and polished. Although steel masts and spars are now being increasingly employed, there is still some call for wood in this direction. In a loft over this department the sails and awnings are made—see Fig. 39. On the same level as the sail loft is the upholstering department—see Fig. 40—and this might well belong to some large city supply stores, so extensive is it and so varied is the work carried out in it. Below are built the smaller boats for the requirements of the larger vessels—see Fig. 37. These are of wood, and are very substantially constructed.

Messrs. Harland and Wolff find it necessary to lay in a very large stock of timber indeed. We were somewhat photo-printing and photographic department—see Fig. 41. Generally speaking and whenever possible the photographic prints are made solely by the aid of the sun, rails being laid on a flat roof at the level of the working floor of the shop—which, we may add, is above the pattern store—so that trolleys carrying the printing frames may be run out on to it. This roof fronts the storage yard, so that a very nearly southern aspect is obtained. There is, however, provision for making prints by means of the electric arc, a glass cylinder with automatic apparatus for lowering a flame arc lamp down it being provided. The other equipment for the quick production of prints is very complete, and there is also a dark room for the development of ordinary photographs.

One of the most noteworthy departments of the whole works is the central power station—shop No. 39. Taking the electrical installation alone, it contains 4000 kilowatts, or sufficient power, if all be at work, to supply current enough to light continuously nearly 133,000 8 candle-power incandescent lamps taking 30 watts each. Fully to appreciate what this means, let us say that a well-known town with 300,000 inhabitants and an equivalent of some 120,000 8 candle-power lamps connected has a total capacity of but 4500 kilowatts. It is, moreover, a perfectly arranged plant, and it is run just as though it were supplying current for power and lighting purposes to a large town instead of just to one single works. We have spoken several times in the course of this article of the electric driving in different parts of the works and of the various systems of lighting employed, but what we have said cannot have conveyed an adequate idea of the

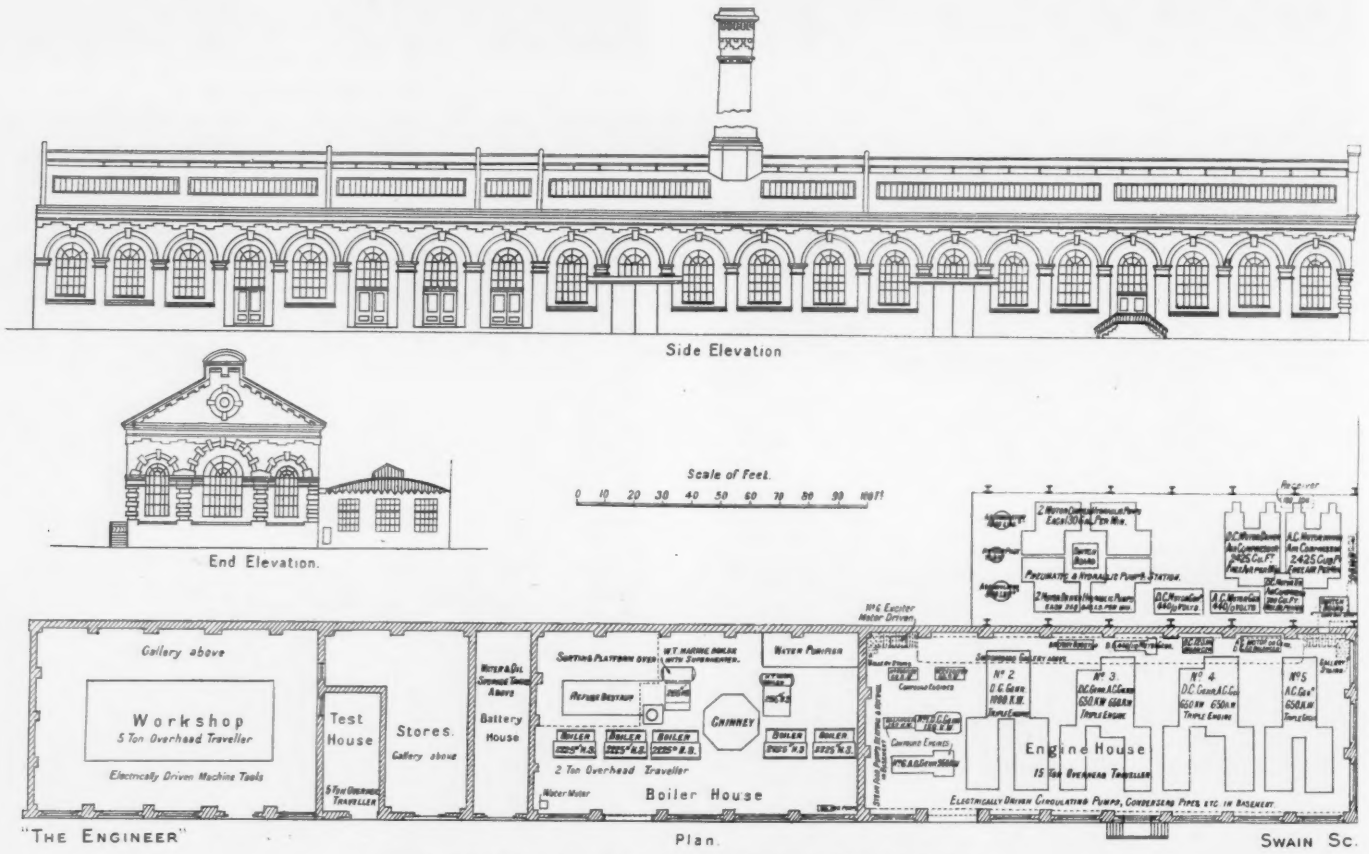


Fig. 43—ELEVATIONS AND PLAN OF THE POWER STATION BUILDINGS

radial drilling machines on the uprights of the building; a large pillar drilling machine; an hydraulic riveter; an hydraulic and other punching and shearing machines; screwing and other lathes; a horizontal revolving head planing machine; a $\frac{3}{16}$in. plate shearing machine to take in up to 5ft. wide; and a circular cold saw driven by a 2 horse-power motor running at 700 revolutions per minute. The building is similar to that just described, saving that it has a "Belfast" roof. There is a 10-ton overhead travelling crane in one bay, and three cranes of different capacities in the other bay. Space alone prevents us from dealing at greater length with this shop and with the fine work which it turns out.

Next in order of rotation comes shop No. 31, which is devoted to coppersmiths' work, of which a great deal is, of course, necessary in shipbuilding. This shop is divided into three bays, and in the centre of these there is an overhead runway, on which run monkeys carrying differential blocks. It is arranged to come vertically over a series of smiths' fires and to support the copper pipes, &c., while these are being heated and operated upon. Work on the pipes is carried out both by pneumatic and hand hammers, and hydraulic pressure is also employed. For this purpose a compact set of three-throw electrically-driven pumps, supplied by Laurence, Scott, and Co., has been installed. The motor driving is of 20 brake horse-power, and it works at 420 volts and 900 revolutions per minute. It supplies pressure water to the cylinders of a series of bending machines. The further equipment of the shop includes a cold saw driven by a 6 horse-power motor; a power hammer driven by belt from a 10 horse-power motor; numerous vertical radial jib cranes with monkeys, these cranes being either of the pillar type, or attached to the uprights of the building; dipping baths, both acid and bitumen; small lathes, drills, shears, &c., driven from a surprised to find what sum of money this represented. Rarely, we were informed, did the value of timber in stock fall short in value of the sum of £150,000. The firm holds that no timber is so well matured as that in which Natue alone has done the work. Even with this there is chance of warping and cracking, but they maintain that such happenings are much more likely when artificial methods have been employed than when they have not. Buildings Nos. 36, 37, 38, and 50 are sheds devoted to the drying of timber. They altogether cover an area of 79,200 square feet. The sheds themselves are formed of steel uprights carrying light roofs. The sides are open—see Fig. 42. Before being stored the logs are sawn up into approximately the sizes in which they will eventually be used, and are then stacked horizontally with wedges between each board or plank. In the sheds passage ways are left between the various stacks of timber, these passages running at right angles to one another, and being lit partly by flame arc lamps and partly by electric incandescent lamps, so that even at night time any particular lot of timber can be reached. Narrow-gauge tramways with turntables traverse the storage yard in all directions, and run under the sheds. As we shall show later on, these are not the only places set apart for the storage of timber.

Before going on to describe the central electric power station—No. 39—we may first briefly refer to the two other shops, Nos. 40 and 53, to which access is obtained from the storage yard. No. 40 is first of all used for the storage of patterns, principally of those which are either more or less out of date or infrequently used. We notice, however, that the same regularity with regard to numbering and registering was carried out with them as with the other patterns more frequently in use. No. 40, in addition to being employed for storing patterns, also contains a size of the undertaking; nor, indeed, will it be easy to do it. However, we will make the attempt.

First, let us say that from start to finish no expert assistance was sought outside the ranks of the firm. No architects and no outside engineers were consulted. The whole scheme was initiated and carried to successful completion by the firm's own engineers. It was no easy task which had to be accomplished, for it was necessary to take so many things into consideration. For instance, the demand for current in a shipyard is by no means constant either as regards its quantity or the position in which it is used. At one time there may be a very heavy load in one part of the yard; at another an equally heavy demand in quite another place—this, of course, in addition to the more or less regular supply given to the machine shops and to the various sheds, &c., in the yard. Then, too, the question of the best form in which to generate and use the electrical energy had to be decided, and this was anything but an easy matter. Had it been possible, it would, no doubt, have been far simplest to lay down three-phase plant throughout, for complications would have been fewer and the upkeep of the numerous motors would have been comparatively cheap. But it was not possible because many of the machines had to run at different speeds at different times, and to vary the speeds of synchronous three-phase motors is only practicable within certain circumscribed limits, and then only with extra machinery and complication. Moreover, the electrical appliances on board ship, whatever may ultimately be the case, are at present, for by far the most part, driven by direct current—generally speaking at a pressure of 110 volts. Now, to have a pressure of only 110 volts for supplying power from a central station to even such a more or less restricted area as the works of

THE CENTRAL POWER PLANT

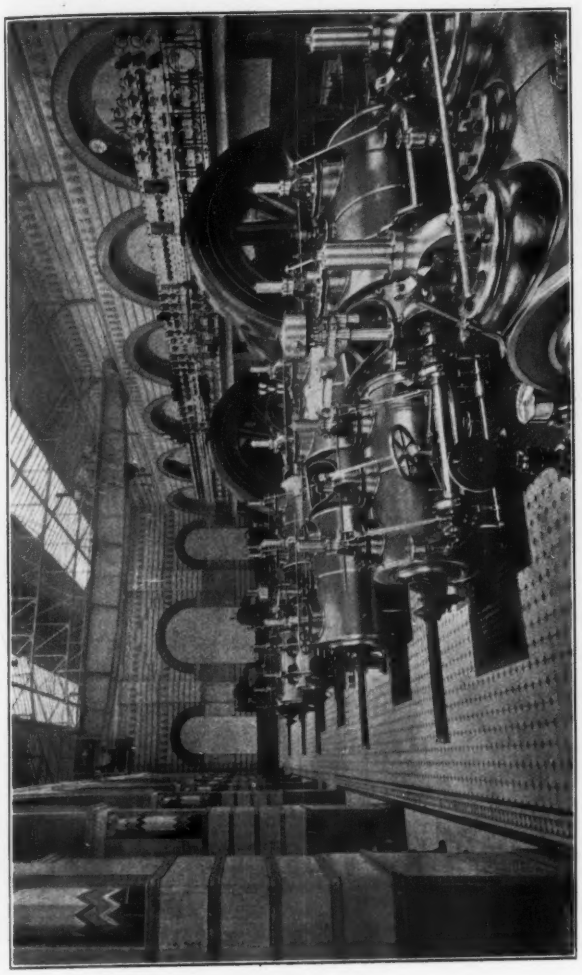


Fig. 45—THE ENGINE HOUSE

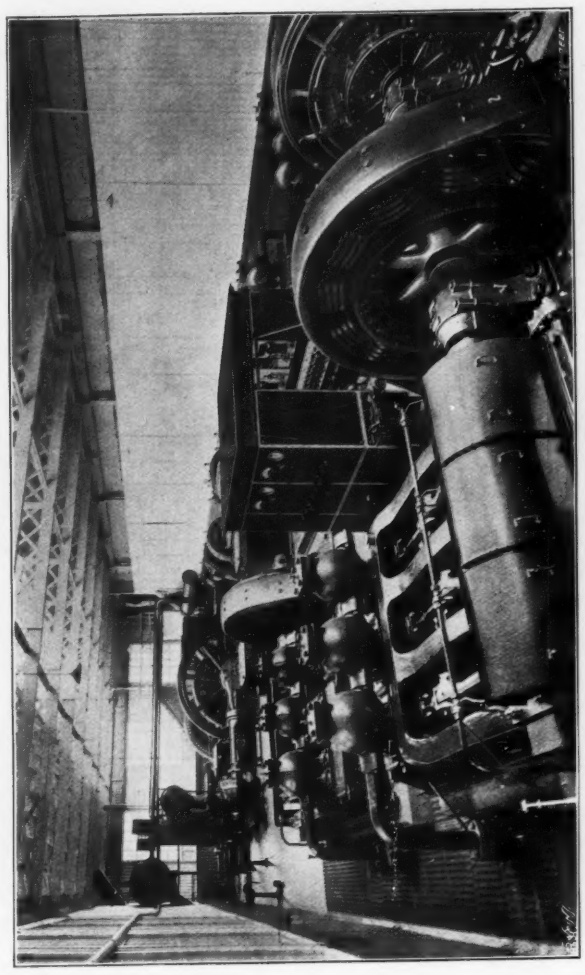


Fig 47—HYDRAULIC MACHINERY

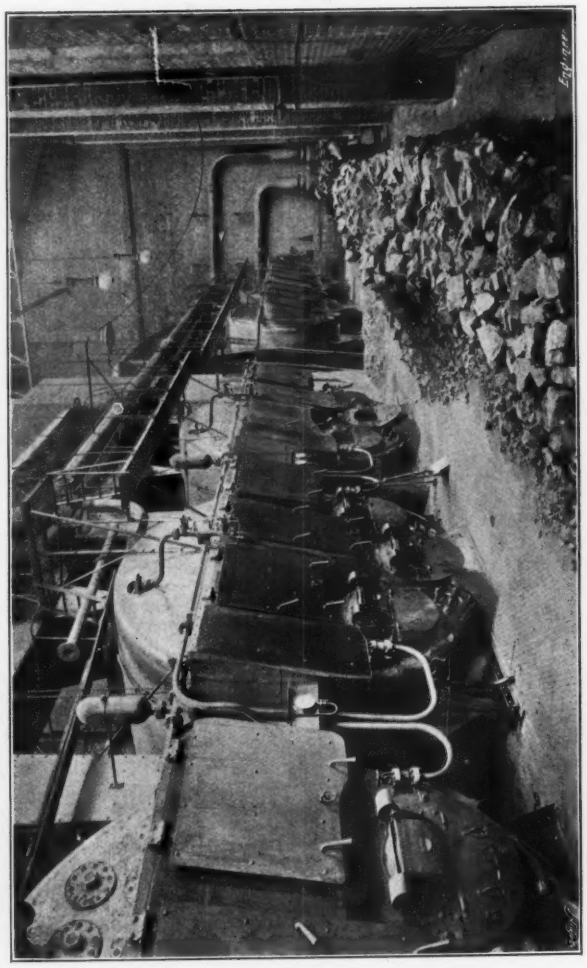


Fig. 44—THE BOILER HOUSE

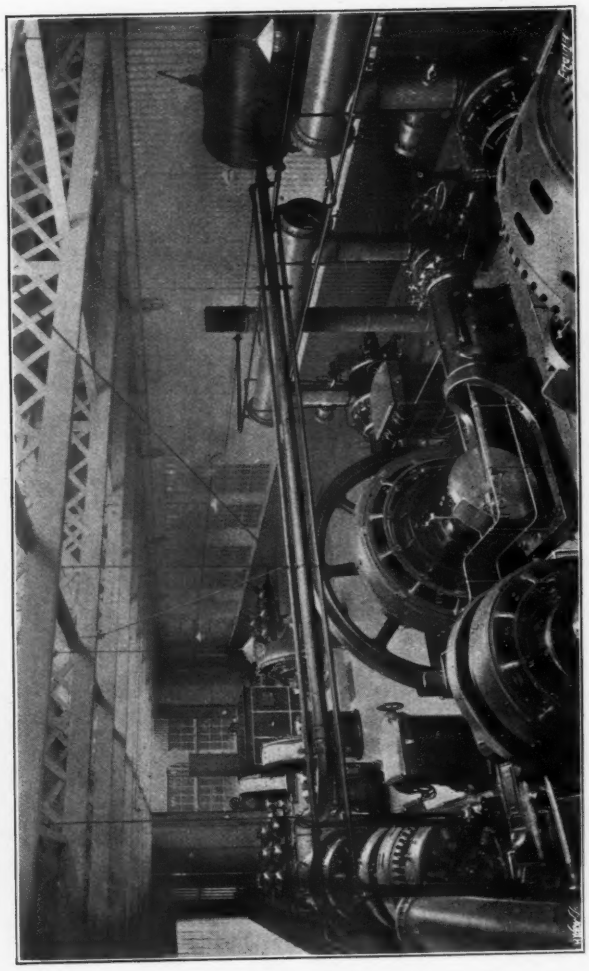


Fig 46—PNEUMATIC MACHINERY

Messrs. Harland and Wolff would have entailed a very heavy outlay on copper mains, so that a supply exclusively at this voltage was out of the question. Yet tools had to be driven, some at fixed and others at varying speeds; the ship appliances had to be run and tested before being sent out; and then there was lighting, both arc and incandescent.

After careful consideration of the whole matter it was finally decided to install a dual plant, and to lay down both alternating and direct current machinery, and to generate the electricity at about 450 volts. It might be urged that to do this was to adopt a complicated system, and would lead to trouble, but the reply to this is that it is not so. The whole scheme has been so judiciously thought out and put into execution that everything works with perfect smoothness. The whole forms what may certainly be described as a model plant.

A specially designed red brick building was erected to contain this central station. It measures some 415ft. long by 68ft. wide, and in addition there is an annexe about 136ft. long by 47ft. wide, which contains some electrically-driven hydraulic and air-compressing machinery. The building is of handsome design both inside and out, the interior of the engine-room calling for special comment, which we shall make in due course. The engine-room and boiler-house are separated one from the other by means of a substantial brick wall, there being only one small connecting doorway between the two, so that the dirt and dust of the latter are successfully kept apart from the former. A plan and elevations of the building are given in Fig. 43, page xii.

It is, perhaps, not wonderful to find that the main boiler equipment consists of ordinary marine boilers manufactured by the firm. They are accustomed to make such boilers, and they thoroughly understand them; but they are not employed entirely to the exclusion of all others, for there are also two marine type water-tube boilers. There are altogether seven boilers. Five of these are of the ordinary marine type, with return tubes and combustion chamber, and they each have three furnaces. Resort has not been had to any form of mechanical stoking, hand firing alone being employed. Arrangements have, however, been made by which oil may be used as fuel, all the necessary pumps and fittings and storage being provided. We understand, however, that this system of firing is regarded as a standby for use only in cases of emergency, though in a long course of experiments with it, made some time ago now, with the idea of obtaining information as to the use of oil fuel for marine purposes, some excellent results were obtained, and a valuable series of data compiled. The five boilers have each a heating surface of 2225 square feet, so that together they possess a total heating surface of 11,125 square feet. The two other boilers each have a heating surface of 2155 square feet, so that the total heating surface amounts to 15,435. A view in the boiler-house is given in Fig. 44, page xiii.

One of the two additional boilers just mentioned is of the ordinary hand-fired Babcock and Wilcox type, but the other, although of this same type, is in a special setting, and calls for special mention. We have several times alluded to the means employed for collecting sawdust, &c. This and other refuse produced in the works and in the various ships which may be fitting out is carefully collected and taken in carts to the boiler-house. Here it is all elevated by means of an overhead traveller of 2 tons capacity to a sorting platform arranged over a refuse destructor, where it is sorted and fed into a shoot leading down to the destructor furnace, which is of the Meldrum type. It is astonishing the amount of refuse which is collected in the course of the day, and we were informed that it certainly amounted to 20 tons. The heated gases produced during the burning of it are utilised in the seventh boiler, which is of the Babcock and Wilcox type, and is provided with a superheater. The chimney to which all the flues from these boilers lead is of red brick, 180ft. high and 8ft. diameter at the top. The water for the boilers is passed through a Paterson feed-water purifier, which is placed in one corner of the boiler house. For measuring the amount of water taken from the town mains there is a water meter in another corner. The boilers, we may add, work at a pressure of 200 lb. per square inch.

The engine-house—see Fig. 45—is an exceedingly fine building some 168ft. long by 62ft. wide. It is lined throughout with glazed bricks, the majority of which are white, though there is a skilful admixture of light shades of green, brown, blue, and grey, the whole producing a most harmonious and tasteful effect. The floor is composed of white and green tiles, and an entrance is obtained up two short flights of steps and through a two-leaf door which is decorated with a really fine example of wrought iron designing. This we were informed was the work of one man—a craftsman of Belfast. The roof is carried on pleasingly curved principals and certainly adds to, rather than detracts from the general appearance of the interior. The illumination is perfect. First of all the roof is heavily glazed; then there are three windows facing Queen's-road and there are six windows facing the storage

Fig. 48—VIEW OF HALF NEW GANTRY DURING CONSTRUCTION

Fig. 49—THE FLOATING CRANE REACHING OVER A VESSEL

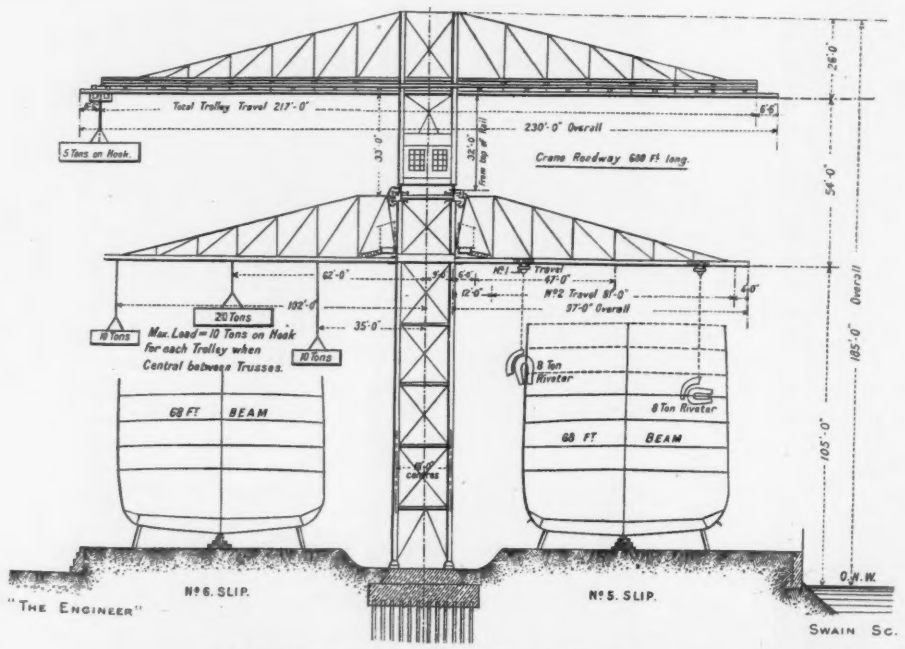


Fig. 50—SHIPBUILDING GANTRY OVER SLIPS 5 AND 6

yard. These are formed in arched recesses, the corresponding recesses in the other walls being also arched, though they have no windows in them. In a word, it is decidedly the most handsome engine-house that we have ever seen.

As regards the machinery, we must first of all give voice to a lament—it is largely of continental manufacture. This, in a works where nearly everything else is

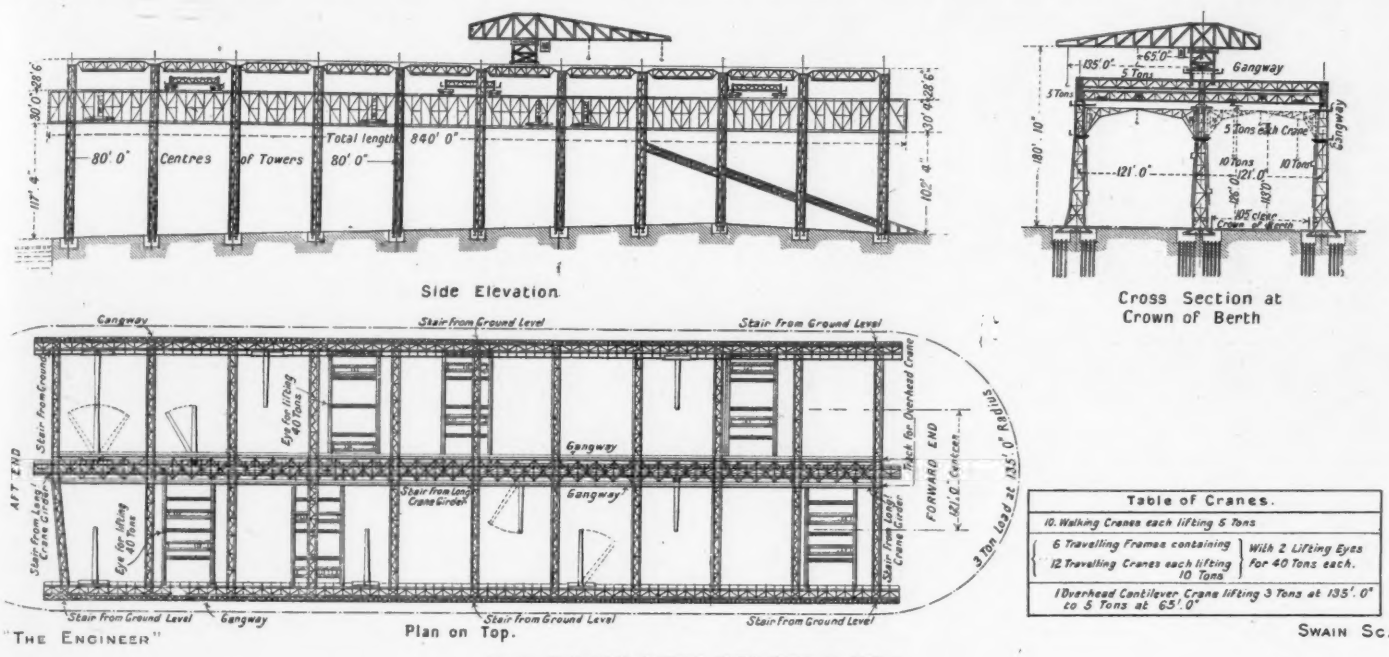

Side Elevation
Cross Section at Crown of Berth
Plan on Top.
"THE ENGINEER"
SWAIN Sc.
Table of Cranes.
10. Walking Cranes each lifting 5 Tons
6 Travelling Frames containing 12 Travelling Cranes each lifting 10 Tons
With 2 Lifting Eyes For 40 Tons each.
1 Overhead Cantilever Crane lifting 3 Tons at 135'. 0" to 5 Tons at 65'. 0"

Fig. 51—THE NEW GANTRY OVER SLIPS 2 AND 3

above to the necessity for different voltages for various purposes, and it will be seen that a large variety of voltages are available, these varying from 60 to 460 at the generators. The two motors in this set are each of 150 horse-power, and their input when working normally is 440 volts and 280 ampères. They work at 600 revolutions per minute. The remainder of the equipment consists of two balancers, both made by Lahmeyer. The

A few words may here be said regarding the network of mains laid throughout the works and the sub-stations which are placed at different points. 82 separate circuits are run from the power-house. The cables employed vary in cross section from .007 square inch to .5120 square inch, and the total length is over 500 miles. There are nominally but three sub-stations, though there are several parts of the works which are sub-stations in the

British, certainly gives rise to remark, but we understand that it was unavoidable. No British firm was, at the time when the plant was ordered, able to guarantee delivery of the type of plant required within anything like a reasonable time, for it was during the lucky period when our electrical firms were so full of orders that they did not know which way to turn. So, reluctantly, Messrs. Harland and Wolff had to go abroad. It was regrettable but unavoidable. Having expressed our sorrow at such a fine order having gone out of the country, we have nothing but good things to say regarding the plant itself. It is excellent in every way, and has given every satisfaction since it was put to work.

There are first of all four main generating sets. Each is driven by a four-cylinder twin tandem triple-expansion horizontal engine of the drop valve type, made by Sulzers, of Winterthur. They are very fine engines indeed, both in design and in finish, which is of the excellence which is always a noticeable feature in the engines sent out by this firm. Each engine has two cranks driving on to one crank shaft, on which are mounted the electric generators. That marked No. 2 on the plan given on page xii. is a direct-current generator, and it has a normal rated capacity of 1000 kilowatts at 460 volts, though it can stand an overload considerably in excess of this. The speed is 100 revolutions per minute. The generator was made at Frankfort by the Lahmeyer Company. The sets marked Nos. 3 and 4 are identical one with the other, and differ from No. 2 in the fact that two generators, one three-phase and one direct-current, are carried on the shaft driven by the engine, which, however, is of the same type as that first mentioned. These smaller generators are each of 650 kilowatts capacity, and they work at a pressure of 460 volts, and at a speed of 107 revolutions per minute. Set No. 5 has only a 650-kilowatt three-phase alternator, also of 60 volts, and of the same type and speed as the generators in sets 3 and 4. Each of these four generating sets is provided with an electrical barring gear.

The other equipment of the engine-house is very complete. First of all reference may be made to No. 6, which consists of a three-cylinder vertical compound engine by W. H. Allen, Son and Co., Limited, of Bedford, coupled direct on the same bed-plate to a 350-kilowatt three-phase alternator. Set No. 1 is also driven by a vertical compound Allen engine, the shaft of which is prolonged in both directions. On one end there is mounted a direct current generator having four poles and generating current at 440 volts. Its capacity is given as 342 ampères, and it runs at 360 revolutions per minute. The other end of the shaft carries a 120-kilowatt balancer, the two parts of which are marked 230 volts, 261 ampères, and 220 volts, 272 ampères respectively. Next to this are two exciter sets, each consisting of Allen's compound engines driving two-pole inverted direct-current dynamos rated at 60 kilowatts at 230 volts, and running at a speed of 400 revolutions per minute. Close by again is a motor driven exciter supplied by Laurence, Scott and Co., the motor taking 440 volts and the generator delivering up to 78 ampères at 220 volts, at a speed of between 275 and 315 revolutions per minute.

Arranged along the wall opposite to the entrance are the following machines. First of all there are two sets of battery boosters arranged on one bed-plate. In each case the motor is rated at 230 volts at 1000 revolutions per minute, and the generators are arranged to supply current at a normal voltage of 15 and a maximum voltage of 30, the output being 880 ampères and 440 ampères respectively. Then there is a double motor generator by Laurence, Scott and Co., capable of supplying current at any voltage between 150 and 60. We have referred first of these is a direct-current 60-kilowatt machine, consisting of one motor and one generator running at 550 revolutions per minute, and delivering current at a pressure of from 220 to 230 volts. The second balancer has an alternating-current motor, mounted on the same bed-plate, between two direct-current machines. The motor works at 460 volts and 200 ampères, and the two generators can deliver 340 ampères at 220 to 230 volts. This set, we may mention, is intended to be worked backwards as well as forwards; that is to say, either the direct or alternating side can be the motor or generator at will. Running the whole length of the engine-house is a 15-ton electrically-worked overhead travelling crane.

sense that they are distributing centres. Thus to the East Platers' shop no less than 18 circuits are run, these varying in size from .05 square inch to .5 square inch in cross section. From there they are taken on to various other parts of the works, notably to slips 2 to 8, and the north and west Platers' Sheds. The three sub-stations proper are situated (1) at the Alexandra Dock works, hereafter to be mentioned; (2) at the junction of the Mast Shed and Joiners' Shop—buildings Nos. 4 and 5; and (3) at the landward end of the new gantry. To the first-named, seven circuits are run from the power-house. Five of these are of the same size, namely, .2 square inch —three-core cables; one is a .15 square inch three-core

Fig. 52—SHIPBUILDING GANTRY OVER SLIPS 5 AND 6

With a station of such large capacity, and of such varied capabilities, there is of necessity a long switchboard. This is erected in a gallery along the wall opposite the entrance. There are no special remarks to be made about it, saving that the instruments, switches, &c., are all mounted on white marble slabs, and that it is as simply arranged as the multiplicity of voltages, &c., would permit. While on the subject of switching we may briefly refer to the general method employed for lighting the works. The lights in the various shops are switched on from the central station and not in the shops themselves. A regular schedule of hours of lighting up has been prepared and is adhered to.

The auxiliaries to the power station are all arranged under the floor of the engine-house. Here are the steam heaters, hotwell and feed pumps, the electrically-driven circulating pumps, condensers, &c. No portion of this part of the equipment appears above the engine-house floor.

cable, and the last a .3 square inch and .15 square inch three-core cable. To the second sub-station run two single .5 square inch cables and a .15 square inch cable, and it is linked up to the first-named sub-station by means of two sets of 2.19/10's single cables. Two single .5 square inch cables connect the second sub-station with the sub-station near the gantry, to which also a .3 square inch three-cored cable is led from the power-house *viâ* the East Platers' Shed. Both direct and alternating current are, therefore, available from all the sub-stations. It would be quite impossible to describe in detail the wonderful network of cables which is run throughout the works, but we may say that for the use of ships fitting out the following cables are run overhead to the water's edge (1) from the Alexandra Dock works two sets of 2.19/10's cables; (2) from the sub-station in the Joiners' Shop two sets of 2.19/10's cables; (3) from the end of slip No. 8 two single .5 square inch cables and two single .4 cables; and a

connection direct from the power-house *viâ* the end of the boiler-house. This is available for vessels lying in the Abercorn Basin. The whole of the circuits may roughly be divided as follows :—(*a*) Arc lights, 450 volts across outers; (*b*) power, three-wire 450 volts; (*c*) power, two-wire 450 volts; (*d*) power, three-phase; (*e*) power, 110 volts, and light 110 volts; (*f*) office and station lights, 220 volts, either two-wire or four-wire; (*g*) station power; and (*h*) station light. The first four of these circuits are to be found in every department of the works, and the fifth in the majority of them.

The annexe to the engine-house—Nos. 51 and 52—contains some most interesting machines. It is here where the compressed air required for various purposes throughout the works is prepared, and where the hydraulic pressure pumps are worked. We will first deal with the air-compressors—see Fig. 46. There are three of these. Two of them are similar in size and design, and are, in fact, exact counterparts one of the other, saving only that the motor in one case is driven by alternating current, and in the other by direct current. In all cases the motor is made by the Allgemeine Company, and the air compressors by the Ingersoll-Rand Company. In the two larger compressors the motor is mounted centrally on a shaft having a crank at each end of it. One of these cranks works the first stage cylinder, which is 30in. in diameter, and has a 30in. stroke. The other crank works the second stage cylinder, which, of course, also has a stroke of 30in., its diameter being 19in. The final pressure is 100 lb. on the square inch, the air being delivered into a large horizontal receiver supported on brackets on the wall. The action of these compressors is automatic, and is governed entirely by the pressure in the receiver. When this tends to increase above 100 lb. on the square inch, a throttling device on the suction comes into play, and air is prevented from entering the cylinders. As soon as the pressure tends to fall again, the air is automatically once more allowed to reach the cylinders. This device works well. The motor for the large continuous-current set is arranged to work with a voltage of 440 to 460 and 220 to 230, and at speeds either of 100 or 50 revolutions per minute. As we have already said, one is an alternating and one a direct-current motor. The two larger compressors can each deal with 2425 cubic feet of free air per minute. The third compressor is smaller, being only constructed to compress 700 cubic feet of free air per minute. It is, however, very similar to the foregoing, and is driven by a direct-current motor working at 440 to 460 or 220 to 230 volts, and at 150 or 75 revolutions per minute.

The hydraulic pressure machinery—Fig. 47—possesses a special interest. There are two pressures used in the works, 800 lb. and 1500 lb. on the square inch respectively. These are produced by two distinct sets of pressure pumps, driven by motors which are automatically worked. The method of control is very ingenious. To begin with, it must be stated that for each set of pressures there are two sets of pumps, one set always being in reserve. For the pressure of 800 lb. on the square inch there are two sets of single-acting three-throw plunger pumps, made by Sir W. G. Armstrong, Whitworth and Co. The plungers have each a diameter of 5in. and a stroke of 20in., and when running at the full speed of 60 revolutions per minute each set is designed to deliver 250 gallons of water per minute at the pressure stated. These pumps discharge into an accumulator weighted so as to give 800 lb. on the square inch, having a lift of 20ft. and a plunger with a diameter of 20.5in. The two sets of 1500 lb. pressure pumps are similar to the foregoing, the stroke being the same, but the plungers are 3½in. in diameter. The capacity of these is 130 gallons per minute at the pressure stated. These discharge into an accumulator, having a lift of 20ft., but with a plunger of only 15in. diameter. All the four sets are driven by multipolar direct-current shunt-wound machines each of 200 brake horse-power when working at their full speed of 60 revolutions per minute, these motors being supplied by the Allgemeine Elektricitäts Gesellschaft, of Berlin. They are separately excited and derive the current for working them from either of two sets of motor generators driven from the supply mains from the central station. One motor generator has an alternating-current motor, the other a direct-current motor, and both of them are constantly running at fixed speed, one supplying current to the armature of one set of pump motors, and the other to the other. By varying the resistance in the field of the generators in each case, the voltage, and hence the amount of current forced through the motor armatures, may be varied, and the range of voltage is between 0 and 440 volts. This alteration of voltage is automatic, and is brought about entirely by the action of the accumulators. If there is a demand for pressure water and the plunger of the accumulator is forced down by the weight upon it, then more work is called for from the motors, and the motor generator works at a higher voltage. If, on the other hand, the pumps are forcing the weighted plunger of the accumulator upwards, then less work is required, and less is accordingly done. The method of altering the resistance in the field of the motor generator is by the use of a rheostat in each case.

Next door to the boiler-house on the side away from the engine-house is a battery room. In this there is an accumulator which has a capacity of 1000 ampère hours, and which helps to afford current for lighting and power at times when the machinery may not be at work. Above this are placed some oil tanks and two water reservoir tanks capable of holding 35,000 gallons. Adjoining this are some stores, and next this again is an electrical testing house where motors, instruments, &c., may be tested. It is provided with a 5-ton overhead crane. To the workshop shown in the plan, Fig. 43, we have already alluded under the heading No. 7. Shop No. 53 is devoted to storing the electrical fittings required for any particular ship either being built or repaired. The floor is divided up into sections, one for each ship.

That part of the works which is known as the Alexandra Dock Works is devoted largely to rough wood working, and to the storage of baulk timber, iron, oil, &c. Nos. 43 and 44 are, timber and general stores. In No. 44—Fig. 32—is something which forms quite a feature of the works, for in it are extensive samples of different styles of decorations for saloons, state-rooms, and cabins. The prospective customer may see ever so many different kinds of decoration, and numerous examples of the fitting up of cabins exactly as they will be on board ship. No. 45 is a storage shed, and No. 46 is devoted to the heavier kinds of wood-working machinery—see Fig. 33. Here are log frame and band saws, planing, mortising, and other wood-working machines, all of them separately electrically driven. No. 47 is the stables, where there is room for some dozen horses, while No. 48 is an oil fuel storage tank with its pump, the former being isolated and surrounded by water. The remainder of the area is taken up with the storage of vast quantities of log timber and iron in various forms. Standard gauge lines run throughout, and on these run several steam jib cranes.

We have well nigh come to the end of our space, but some few words must be said about the facilities for fitting out vessels after they are launched. This work is partly carried out in the Abercorn basin. There are two jetties, which we have already mentioned, and also a long quay provided with a powerful steam-worked three-legged sheer legs, which can deal with weights up to 60 tons, and the overhang of which can be varied by altering the position of the back leg, this being done by means of a large screw. There are also fitting out berths at the opposite end of the works with a 100-ton crane. The equipment also includes a powerful steam-worked pontoon crane made by the Benrather Maschinen Fabrik. This is of such a shape that when at work in the water with a ship between it and the quay, it can lean right over the vessel and pick up its load from the quay—Fig. 49. Its maximum capacity is 200 tons. As already stated, provision is made for taking electric leads on board vessels at the quays or jetties, so that current can be supplied direct from the central station.

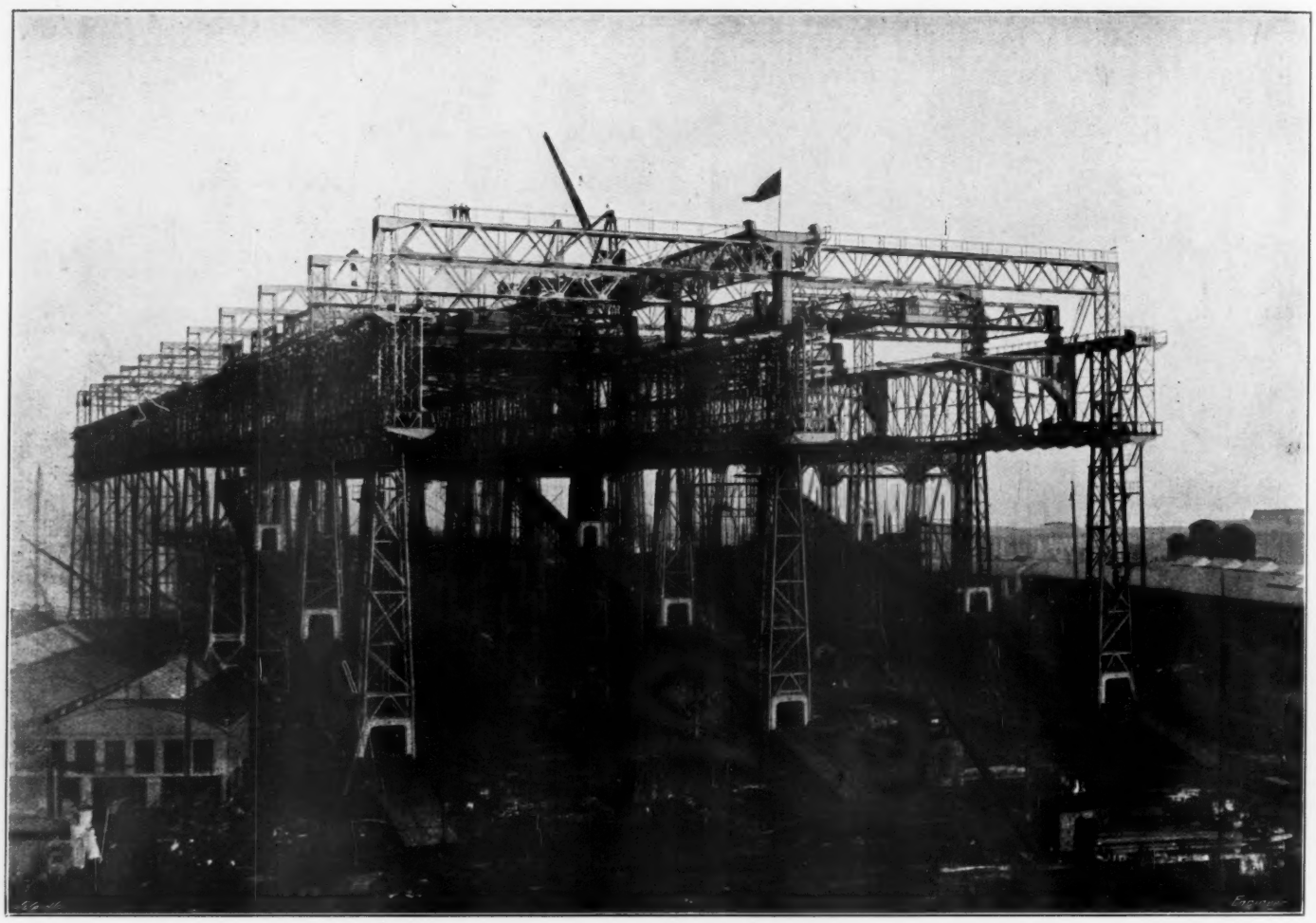


Fig. 53—VIEW OF THE NEW GANTRY OVER SLIPS 2 AND 3

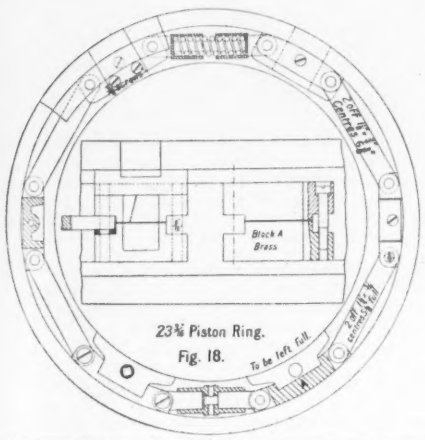
PISTONS AND PISTON VALVES.

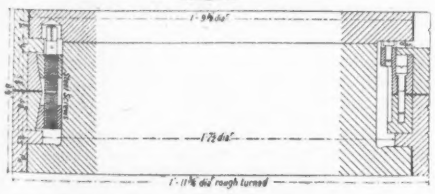
No. II.*

THERE is one fact in connection with high-pressure cylinders which can hardly be over-estimated, and that is the absolute necessity for fitting them with hard close-grained liners, the metal suitable for the general casting of the cylinder not being suitable for the working surface, and metal suitable for the liner not being suitable for the cylinder. Proofs of this have been given over and over again; to mention one instance connected with Sheffield power station, all the cylinders of which are fitted throughout with Buckley's restrained rings and springs. One of the high-pressure cylinders when first put down wore $\frac{5}{16}$in. larger in diameter in as many weeks' running. A new liner was fitted of hard close-grained iron, and to-day this liner is only $\frac{1}{64}$in. larger after four years' constant running, and is a monument to the utility of a good hard close-grained liner.

In Figs. 17 and 18 are illustrated Haythorn's piston rings.

These differ considerably from those already described. The packing consists of two strong rings of L section, which are expanded radially by a chain consisting of flat wrought iron links and double cast iron or brass pads alternately. At opposite sides these links give place to, on one side, a strong spiral spring contained in two half-boxes, and, on the other, an adjusting screw and nut. The link pads are in halves vertically, and between these, threaded on their brass connecting pins, and between one of them and the wrought iron link, is a short spiral spring separating the half-pads against the flanges of the packing rings with a constant pressure. The adjusting screw forces the links round against the spring opposite, compressing it a measurable distance within the half-boxes—never more than $\frac{3}{16}$in. to $\frac{1}{4}$in. for the largest diameters.





It will thus be seen that the vertical action is constant, and just sufficient to produce steam-tight contact between the packing rings, junk ring, and piston flange, and that the expanding pressure, being applied through jointed links, is transmitted radially and equally all round the packing rings.

Fig. 18 is a modification of Fig. 17, specially suitable for horizontal engines, the expanding and vertical actions being the same. The packing rings, however, have their ends produced to the full depth of piston, the flange and junk ring being reduced in diameter to admit of this, thereby obtaining extra wearing surface. In addition to this, on the bottom side are two adjusting screws separating tapered nuts, which, working between two adjoining link pads and the body of the piston, carry the weight of the piston entirely upon the broad surface of the packing rings, and are adjustable to any extent to compensate for wear, so that the body of the piston and its rod can always be maintained in the original central position.

Another novel type of ring is shown in Fig. 19—Allen's piston ring. It is certainly simple, and possesses

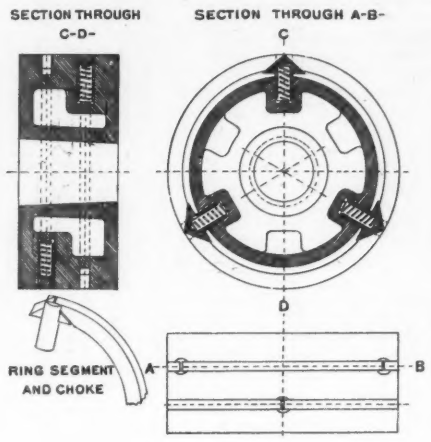


Fig. 19

several very good points. The Allen ring, unlike other rings, is narrow and very deep, and in itself springless, but the element of elasticity is supplied by its being cut into three or more segments, the joints of which are filled steam-tight by wedge-shaped chokes, actuated by spiral springs. The stems of these chokes work in sockets,

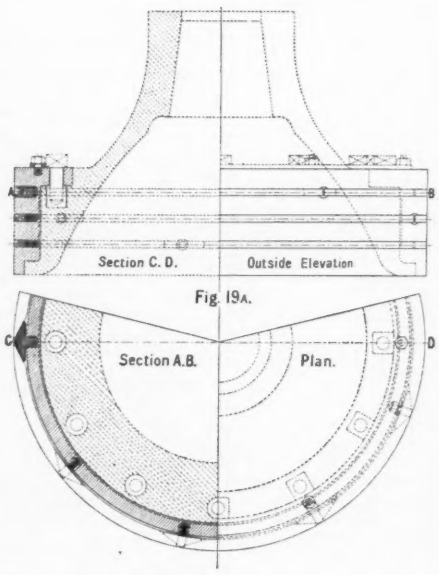


Fig. 19A.

which permit of movement in one direction only, viz., radially. The various rubbing surfaces are ground to make perfect joints, and the workmanship has to be of the highest class. Indeed, such fitting is only possible along the lines of the Allen invention, because this ring never has to be strained into position, and so suffers no distortion. The great depth of the groove and the close sliding fit make a steam-tight joint. The makers claim, in fact, that the Allen ring never becomes steam-packed. It is claimed that the Allen ring, being springless and divided into segments, does not share the tendency of some rings to periodic vibration. In Fig. 19A is shown an application of this type of ring to a 39in. diameter high-pressure piston of a marine engine. We are indebted to Messrs. Frank Stacey and Co., Winchester House, Birmingham, for the two illustrations of this piston. There are, of course, many ways in which the springs for forcing the rings outwards against the cylinder, and sideways against the piston flanges, may be arranged, and the making of special piston and valve rings has now become an industry on its own account. We need only mention without describing such familiar designs as the "Lancaster" ring, made by Lancaster and Tonge, in which a continuous spiral spring is employed, or the rings made by Lockwood and Carlisle, and the Standard Piston Ring and Engineering Company, Limited, in which the spring is composed of alternate parts which press the ring against the flanges and against the cylinder walls.

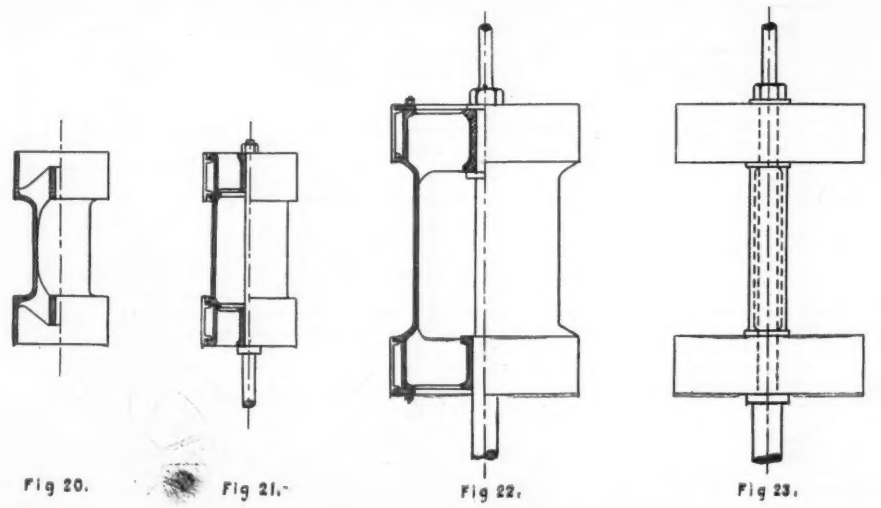
The piston packings above described and illustrated may be taken as representing generally present-day practice. It is surprising to find that after so many years' experience, several large firms use no other type of piston-ring than the ordinary Ramsbottom ring. With the general use of superheated steam which obtains to-day, however, spring rings restrained by a substantial locking device are no doubt the most favoured and the most suitable.

PISTON VALVES.

The piston valve engine, which was much despised only a few years ago, and classed as a steam eater, may now be placed among the most economical of prime movers. Quick-revolution engines have all cylinders fitted with distributing valves of the piston type, and quite a large number of slow-revolution engines are being fitted with piston valves driven through trip gears. Already two firms in the country have taken up the manufacture of slow-speed piston valve engines as standard practice, and have obtained good results; in fact, one of the most economical of engines of recent times was fitted with piston valves, viz., the engine built by Messrs. Cole, Marchent and Morley for a mill in Belfast, full particulars of the test of which were published in THE ENGINEER of June 2nd, 1905, and further particulars of an engine with similar gear will be found in THE ENGINEER, July 19th, 1907.

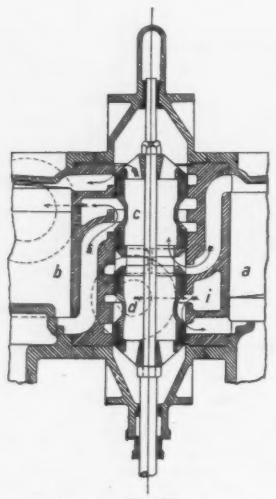
The piston valve engine is therefore finding favour, and considering the great simplicity and the ease with which the practically frictionless valves can be actuated, it has great advantages. These may be summarised as follows:—It is simple. It is perfectly balanced. It is the easiest of all valves to actuate. If properly designed it will automatically adjust itself and keep steam-tight; and lastly, it is suitable for the highest steam pressures and superheat. The majority of piston valve engines are of the vertical type, and those of the horizontal type have the piston valves arranged to work in a vertical position. This is no doubt the best and most natural position, and has proved the most satisfactory in practice. As already stated with reference to pistons, the ideal piston valve would be a solid one, but, of course, with a solid valve there is no provision for adjustment when wear has taken place. Owing to the difficulty of making piston valves work satisfactorily when fitted with spring rings, particularly when working with high pressures and superheated steam, solid valves, or valves fitted with solid floating rings, have been and are very largely used, more especially for quick revolution engines. These have been found highly satisfactory, and many years' experience has long since shown that engines do not rapidly become wasteful; in fact, many examples might be quoted from actual practice to show that the wear of solid floating valve rings, if properly designed and correctly driven, will be hardly measurable after several years' running. The fact that the leading quick revolution engine builders have used little else but solid floating rings for their valves for years, and have been able to compete with makers of slow-speed engines goes to prove that solid rings give satisfaction.

In the case of solid piston valves, or valves fitted with solid floating rings, a small amount of clearance must be allowed for the valves to work. Under ordinary conditions, with steam at about 150lb. pressure per square inch, the minimum clearance allowable is about .004in. for, say, a 10in. diameter valve; but if the steam is superheated, say, 100 deg. Fah., at least double this clearance is necessary owing to the difference in expansion and dis-



* No. I. appeared June 18th.

tortion of the valve and cylinder due to the increased temperature. If the engine works continuously under a specified degree of superheat little better results may be obtained from an adjustable piston valve, but when the engine works with saturated steam the clearance of the valve will be excessive and cause leakage. This is particularly noticeable in the case of engines which are entirely controlled by the governor varying the degree of expansion, as when the valves are made free enough to work satisfactorily with superheated steam, the leakage when working with saturated steam is sufficient to cause the engine to run away when working at no load.



"The Engineer" Fig. 24.

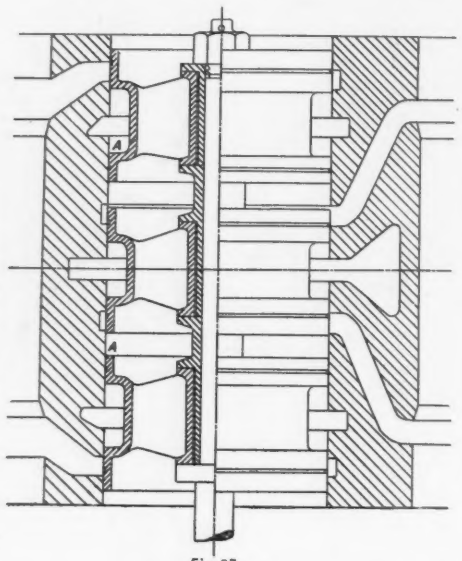


Fig. 25.

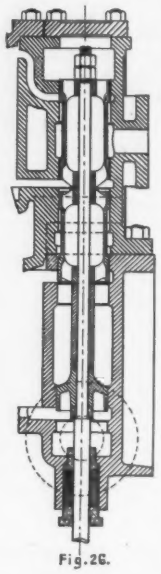


Fig. 26.

Owing to the simplicity and reliability of the piston valve, combined with the ease with which it can be actuated, it is used for a large variety of purposes, including quick revolution land and marine engines, rolling mill engines, winding engines, &c. When driven by an eccentric in the ordinary way, direct from the crank shaft, the valves for one cylinder usually take the forms shown in Figs. 20 to 22. The last two are shown fitted with solid floating rings. The design shown in Fig. 21 is suitable for medium size valves, but is not to be recommended for large engines. For large engines with long strokes the valve is often made in the form of two pistons, as shown in Fig. 23, but this can only be done when the cylinder is arranged to exhaust from each end. This has the advantage of keeping the inlet steam—which is usually admitted past the inner edges of the valve—from close contact with the cooling action of the exhaust steam. A smaller valve can also be used, as there is no need to provide a passage through the centre of the valve for exhaust steam. It is commonly thought by those not acquainted with piston valve engine design that piston valves necessitate excessive clearance volume, due to the arrangement of the ports. This is an erroneous idea, as it is possible to design cylinders for slow-speed engines with a clearance volume of not more than 5 per cent., and even in the case of quick-revolution engines the clearance volume need not exceed 10 to 12 per cent. if the ports are kept as straight and short as possible.

For small compound two-cylinder short-stroke engines it is common practice to make the two cylinders in one casting with a common distributing valve. A piston valve suitable for this type, as used by several well-known engine builders, is shown in Fig. 24. The arrangement really consists of two valves, one above the other. It has the advantage of requiring only one set of valve gear, but it has the disadvantage of necessitating one long port to each cylinder. In practice, however, the advantages of simplicity and cheapness seem to outweigh the slight loss in economy, if we are to judge by the number of engines built with this valve. It is only suitable, of course, for two crank compound engines with cranks opposite. The steam distribution is similar to that of an engine fitted with a separate valve and gear to each cylinder. The valves C D are in the form of hollow sliding sleeves, and these are placed in line with each other on the same rod as shown. Steam is admitted to the high-pressure cylinder a from the cavity i by the lower valve, and is exhausted therefrom into the interior of the sleeve. Thence it passes into the low-pressure cylinder b, being distributed by the upper valve acting like an ordinary D slide valve. The defect of the long ports, &c., is not quite so great as may be at first imagined, but an improvement of from 3 to 5 per cent. in economy may be obtained by fitting valves to each cylinder and cutting the clearance down to a minimum. This may seem a small amount, but it appears to have more value when the year's coal bill is considered. Another design of valve to fulfil the same purpose is shown in Fig. 25. In this case the ports to the low-pressure cylinder can be made short, but two long ports are required for the high-pressure cylinder, and it has the disadvantage of giving twice as much area for leakage of receiver steam past the valve to the exhaust, *i.e.*, past edges marked A A. In the case of small tandem piston valve engines, unless a stuffing-box is fitted between the cylinders, and a receiver pipe connecting the high-pressure cylinder exhaust to the low-pressure steam chest, it is necessary to cross the ports of the high-pressure cylinder. A neater arrangement for engines of this type is that shown in Fig. 26, which design is due to Mr. W. H. Allen.

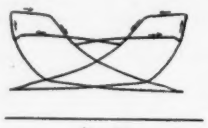


Fig. 28.

Fig. 29.

In the case of high-pressure cylinders of compound and triple-expansion engines, particularly when variable expansion gear is used in connection with a distributing valve driven by a simple slide valve motion, very small openings are given to the steam inlet, especially at early cut-offs. To overcome this difficulty, Messrs. A. Borsig and Co., of Berlin, have designed a piston valve, as shown in Fig. 27. The steam enters internally, and is guided by the edges of the shell or liner bridges. The exhaust is effected past the outer edges of the valve and through the interior. The internal edges of the valve have a covering which is smaller than the inlet covering on the edges of the liner bridges. Upon the commencement of the admission of steam, the cylinder ports and the shell chamber are consequently already in communication through a large free passage, so that full advantage can be taken of the several openings in the shell; whereas in the ordinary double or triple-ported valves larger ports are required and larger surfaces are exposed to leakage. In this design ordinary cylinder ports only are required, and, if anything, less leakage of initial steam should be able to pass this valve than one of ordinary construction, owing to the fact that after steam has been cut off by the central portion of the valve, an additional shutting off is effected by the slide valve closing over the main ports. Again, owing to the large bearing surface of the valve, the latter is well supported, and wear should be reduced. As in the case of trick slide valves, the passage between the shell and the main valves during a portion of the stroke forms one enlargement of the cylinder clearance space. This, however, is of no importance, because this enlargement of the clearance space is restricted to the short period of time at the commencement of the expansion—from the cutting off through the slots in the liner to the cutting off from the main port, and to the short period at the end of compression from the opening of the main port up to the opening of the slots in the liner; and, furthermore, as will be seen from the diagram shown in Fig. 28, which is taken from the chamber between the liner and the main valve, both on the opening of this space to the main port and also on the opening of the slots in the liner, on each occasion the

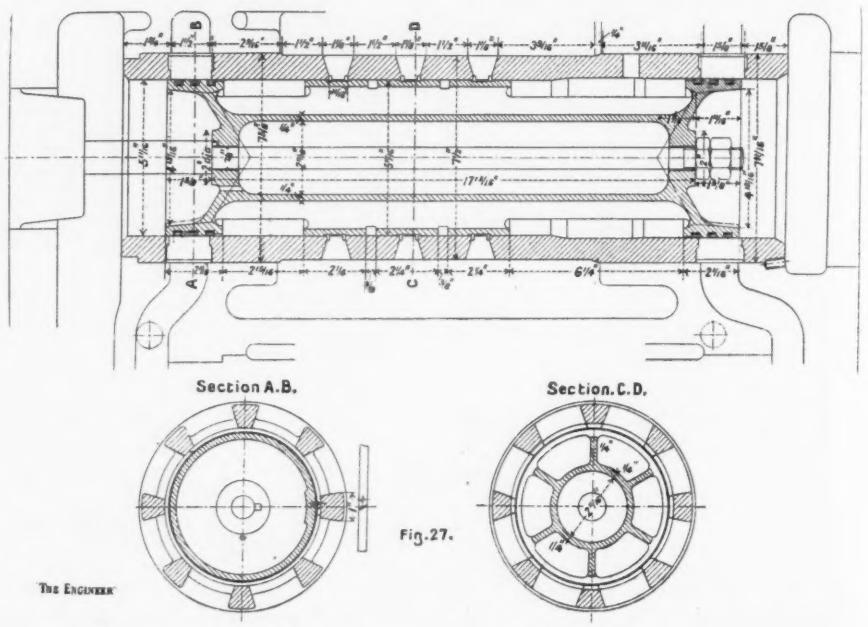


Fig. 27.

FIG. 30.

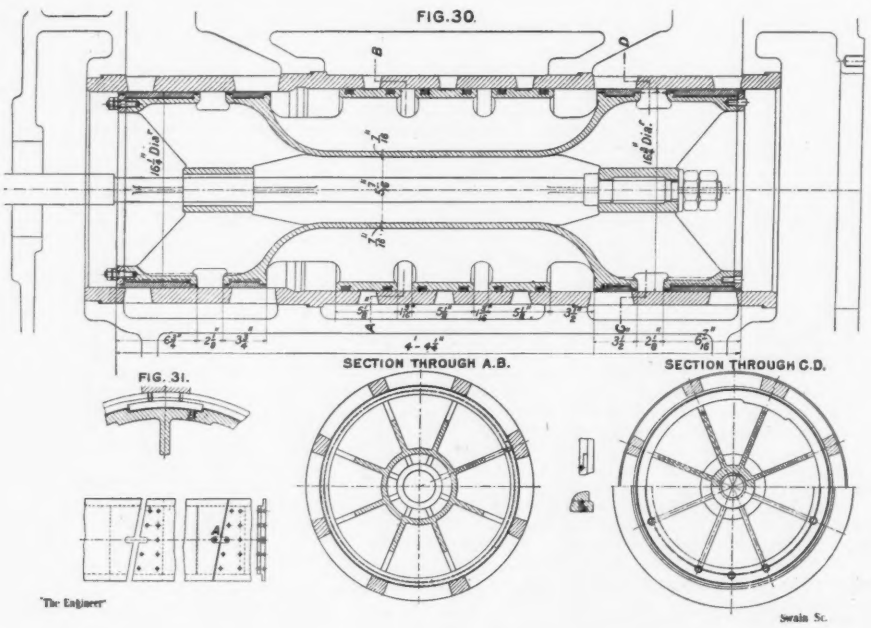


FIG. 31.

steam on either side is at almost equal pressures. The connection of the space between the liner and the valve body with the cylinder clearance at the end of compression is also sometimes of use, as thereby the high compressions (which repeatedly cannot be avoided) are rendered milder. In Fig. 29 is shown an indicator diagram from a vertical single-cylinder condensing engine, with cylinder 350 mm. diameter by 300 mm. stroke, running at 230 revolutions per minute, built by A. Borsig, of Berlin. Although the cut-off is very early, it will be noted that the steam admission line is very good.

The small valve illustrated is cast in one piece and fitted with three rings of the Ramsbottom type at the ends only. As will be seen, these are cut at an angle at the joint and pegged to prevent them turning round. The ports are cast in the liner, and afterwards recessed slightly at the cutting off edges. This ensures an accurate cut-off and a good admission at the point of lead. As the drawing is fully dimensioned and fully detailed, further comment is unnecessary.

Fig. 30 is a detailed drawing of a larger size valve of similar design, but arranged with double ports for exhaust, and triple ports for steam. In the actual engine from which this detail is taken there are two valves working side by side for the one cylinder. In this case, as will be seen, spring rings are fitted to all edges, Ramsbottom rings being fitted to the central portion, and a special design of spring ring extending the whole width of the faces where the valve cuts off from the main port. The Ramsbottom rings are lapped at the joints and prevented from turning by means of a peg—see detail, Fig. 31. The two inner broad rings are sprung over into position, while the outer rings are held in place by junk plates. The joints in these rings are cut at an angle—see detail, Fig. 31A—and are provided with a special lap or tongue piece, which is riveted to one side of the joint, and left free to move against the other. This lap piece, which fits behind the whole width of the rings at the joints, is provided with a raised portion or tongue marked A. This effectually prevents steam passing between the ring and the liner at the joints. Again, as the lap piece is recessed into the valve body casting, as will be seen in detail—Fig. 31 at B—the rings are prevented from turning round. The greatest possible care has been exercised in the design and manufacture of these valves.

THE RAND AS A MARKET FOR ENGINEERING PRODUCTS.

By WILLIAM BLANE, M.I. Mech. E.

No. III.*

THE former articles on this subject dealt with the general conditions relating to the Rand as a market for machinery and the classes or kinds of machinery mostly used on the mines. It is now proposed to show how orders are given out and secured. At so great a distance, the question of agencies is at once suggested, for, if he would secure anything more than a stray order, the home manufacturer must either have an office in Johannesburg or be represented there by some reliable firm or person. The cost of keeping an office in Johannesburg is so great that the latter course, viz., that of arranging an agency with a local firm, is almost exclusively adopted. For the same reason, local representatives must have more than one agency or they can not hope to cover expenses; therefore, the same house would represent, say, a firm of boiler makers, one of engine builders, another of tube makers, a fourth for rock drills, and so on; care being always taken that the makers represented in any one office do not produce articles which would bring them into competition with each other. In this way it comes about that there are about a dozen firms on the Rand, each of which can deal with a specification for the full equipment of a mine, naming in their tender the various makers by whom the goods would be produced. The principals of these local firms are themselves engineers, and their staffs are in every way equal to those of the consulting engineers who place the orders; indeed, some of the most successful consulting engineers on the Rand have come from the staffs of mercantile engineering houses. Here, then, at the very root of the business we have exceptional conditions, for, as stated in a former article, the consulting engineers of the Rand are drawn from the best the profession produces, while the men who first read their specifications are engineers whose practical experience and technical education command the respect of their brethren who for the moment are, to use a phrase often bantered between them, "on the other side of the counter."

The nature of an agency is usually that of an exclusive buying and selling agreement, by which it is arranged that the makers will sell only to the agents and the agents will purchase such goods as the makers produce from them only. The makers are, as a rule, left free to supply to the district direct, but in doing so would pay the agent a small commission on the price obtained. Makers rarely now contribute any cash payment towards the agent's expenses, the agent preferring to allow for everything in making up his tender. This eliminates a former fruitful source of annoyance, and ensures that the agents will either secure orders or give up the representation as unremunerative. The pigeon-holing of agency agreements has kept many a firm tied up for years to an agent who was either too busy or too careless to do anything for it. On the other hand, agents have been kept out of the market by having agreements with manufacturers who were too busy at home to allow of their posting them in the data essential to the making up of a tender. There should be thorough transparency between makers and agents, and where this has obtained there has never been failure to secure business. The maker should unreservedly give up his costs and profits to the agent, and allow him a reasonable latitude in case of extra keen competition, and the agent should send to the maker a copy of every tender submitted, showing how his ultimate figures are arrived at, including his own prospective profit. A clause to this effect, if inserted in the agreement, would go far to guarantee a good understanding.

When tenders are wanted, specifications are sent out to the various firms likely to figure on them, no advertising being now done. The tenders have, as a rule, to be returned within a few days after the receipt of the specification. The price submitted usually includes delivery on the site of erection, duty and all other charges paid. The maker's name must always be stated, and the time in which delivery will be guaranted, subject to the usual fire and strike clause. The penalty for late delivery is embodied in the specification, and the tenderer must accept it. This varies according to the urgency of each case, but usually works out at about 1 per cent. of the delivered value of machinery for every week's delay beyond the contract time. This penalty clause is absolutely essential when dealing with orders which have to be executed by firms at so great a distance, more especially as time is the essence of every contract. Each firm in tendering states the time in which it will deliver, and, as the mines cannot be started till the machinery is erected, the tender guaranteeing the quickest delivery is often accepted, even although its price may be higher than that of others.

In every case tenders are submitted in the name of the local agent, although the maker's name is invariably required. The agents' office, if thoroughly equipped, contains all the data on which to base the maker's price, delivered f.o.b. at port of shipment, and for this sum he becomes responsible to the maker should his tender be accepted. To the cost f.o.b. is added the freight, landing and forwarding charges, railage, insurance, duty, &c., as well as the percentage which the agent considers necessary to cover the risks, profits, and cost of financing the order. This last item is interesting, if but for the fact that it would be unnecessary if makers were more considerate. The terms of payment as between maker and agent are often cash against shipment, whereas those between the agent and the purchaser are usually one-third on proof of complete shipment, one-third on delivery at the mine, and one-third on satisfactory erection. It works out in this way:—An order is obtained for machinery costing £10,000 f.o.b.; to keep the erecting pit clear the job is shipped in several lots, and with each shipment the documents are presented to the agents' bankers in London for payment according to agreement. Probably from the first shipment to the last would be several months, while the last shipment would possibly be some small part overlooked, but essential to the starting of the job. The bulk of the payment has thus been made by the agent months before he can prove *complete* shipment, and only then does he get his first payment of one-third the price tendered. Bad debts are unknown between agent and Main Reef purchasers; therefore, if if the maker has confidence in the agent, his money is perfectly secure. Why, then, do makers not accept the same terms of payment as the agent, especially when such terms would be considered good in the case of a home order? It is this which has kept some of the best firms in Britain out of the Rand market, because it is evident that agents who are strong enough financially to work on the lines indicated become masters of the situation, and ultimately dictate their own terms. The small firm with little or no capital has often to stand out altogether, and not even submit a tender, while it could secure business easily by the small proportion of its own needs if relieved by the home people of the necessity of financing.

To firms which have not already tried this market as an outlet for their products it might be suggested that a small combination of non-competitive makers, with a good man, loyally supported, as its Rand representative, could scarcely fail to secure a share of the large orders to be given out in the near future. This suggestion is prompted by the fact that nearly all the established agency firms in Johannesburg already represent their full complement of manufacturers, while there is still room for new enterprise. Besides, the danger exists everywhere of old-established houses becoming exclusive, and sometimes, too, being entirely out of the running in price, because of the maintenance of heavy stocks and expensive staffs.

Perhaps nowhere else is there such openness and fairness in the matter of tenders where private companies are concerned. All engineers have their prejudices, and a maker who has produced a satisfactory machine will always be looked upon more favourably than one whose production has given trouble. This is especially the case in Johannesburg, and rightly so, seeing it takes months to get renewals at such a distance; but for the new firm there is absolutely fair play, and every encouragement is offered to the inventor who gives any reasonable hope of a reduction of costs, however small.

Railway locomotives and rolling stock, agricultural machinery, and traction engines, &c., have a wider market than that of mining machinery. But, nevertheless, Johannesburg is the centre of the entire trade of South Africa. Whether it be rolling stock for the N.G.R., an electric light installation for the Cape, or a rock breaker for some dorp in the Orange Colony, tenders are called for in Johannesburg. The machinery merchants, whose headquarters are on the Rand, have representatives in all the coast towns, and in such places as Bloemfontein and Bulawayo, so that by this means alone all business gravitates to that centre. The various Governments, however, often purchase the railway supplies through their agents in London, and of late years a good deal of machinery for the mines has been bought and shipped by London representatives. But even in these cases the manufacturer who has an agent in South Africa has advantages which are self-evident, not the least of these being the fact that there is some one out there to refer to in case of trouble.

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THE ENGINEERING EQUIPMENT OF BIRMINGHAM UNIVERSITY.

WHEN the charter for a University was granted to Birmingham in 1900 it was realised that the equipment for applied science then in existence at Mason College was hopelessly inadequate to the needs of the district. An important engineering centre such as Birmingham needs a University which, while giving a good general education to those who desire it, will specialise in those branches of learning which will train men to take a leading part in its local industries. These considerations had great weight with the Council during the development of the new scheme, and their deliberations resulted in the erection of huge laboratories at Bournbrook, largely devoted to the various branches of applied science. The site, about 25 acres in extent, was given by Lord Calthorpe, and is situated about three miles from the centre of the city. Upon this has been erected the magnificent block of buildings that is to be formally opened on the 7th of July by his Majesty the King. All that is best both in European and American practice finds a place in the various laboratories, in the equipment of which no expense has been spared. The main buildings extend in a semicircle facing University-road, while a smaller line of buildings, including the physics, chemistry, and library blocks, form the diameter of this semicircle. The main block of buildings when finished will consist of the great hall in the centre, with three blocks on each side, but at present only four of these seven sections are completed. The first dome at the western extremity of the main buildings denotes the mechanical engineering section. This contains some of the workshops and the main drawing-office. The latter consists of a large room capable of accommodating 120 students, and is well provided with models of machine parts for the use of junior students. A number of Messrs. B. J. Hall's tilting drawing tables are provided for the use of senior students. Each drawing board is fitted with a carbon filament lamp suspended in a special ball-and-socket fitting, which enables the light to be easily and quickly moved to any position that may be desired. Adjoining the drawing-office is a blue printing room, containing an electric copier and all necessary apparatus for washing and quickly drying prints. On the south side of the drawing-office is the Hall of Machines. This is at present unoccupied, but is to be devoted to machines lent or given by manufacturers for the purpose of familiarising students and visitors with the latest mechanisms and principles of various manufacturing processes. Immediately below this is the machine and fitting shop. This contains about twenty lathes of different sizes—some for high-speed work, embodying the best English and American designs. There are also two drilling machines, each of 4ft. radius, by English and American makers; two milling machines, one vertical boring and turning mill, one planing machine (8ft. by 3ft. by 3ft.), one 15in. shaper, three grinding machines, and numerous small tools common in fitting shops. A large number of Parkinson vices is also provided for bench work. The tool stores are well equipped with drills, taps, dies, gauges, and all kinds of small tools necessary for engineering work. All repairs and alterations for the power station and other parts of the buildings are done in the workshops, so that the training given here is quite practical in character. There is, for example, at present going through the shops a feed-pump which has been designed by students, will be entirely made in these shops, and will, when finished, form part of the power station plant.

Adjoining the fitting shop is the pattern shop. This again is very fully equipped. It contains a 30in. band saw, a 20in. wood planing and thicknessing machine, a 32in. circular saw, a dimension saw with tilting table, and all other small tools, grinders, &c, necessary for a pattern shop. There are also six wood-turning lathes that have been entirely made in the University workshops. The machines of both these shops are driven by three-phase induction motors on the 110-volt 30-frequency supply from the power station. The remainder of the mechanical engineering plant is housed in a small set of buildings to the south-west of the main block. The foundry and smithy are in one building, and each occupies a floor space of 1250 square feet—50 by 25. The foundry is provided with a 2-ton cupola, a brass melting furnace and core stoves, and contains a 3-ton hand travelling crane for carrying heavy ladles. The casting and moulding are done by students, who thus gain practical experience in this kind of work. The smithy has an electrically-driven power hammer, an acetylene plant, and twelve coke hearths for the use of students.

Steam and hot water for heating purposes, together with electricity for lighting and power, are supplied by the power station. This consists of three parts, the boiler-room, gas plant, and engine-room. The boiler-room is 40ft. by 60ft., and the engine-room 50ft. by 100ft., but ample space has been left for future extensions. All the plant has been selected with an eye to its teaching value, but considerations of practical efficiency have by no means been omitted, as the installation has to pay commercially. It is also used as a heat laboratory for senior engineering students, and it is here that the peculiar value of the different types of engines and boilers is to be studied, as it enables direct comparisons to be made between different designs working under the same or different conditions. The boiler-room equipment consists of:—Two steel dry back fire-tube boilers 8ft. in diameter, each capable of evaporating 8000 lb. of water per hour. One of these is hand stoked, and the other fitted with a Proctor mechanical stoker, so that direct comparisons of the two methods of stoking can be made on precisely similar boilers. These two boilers are used for heating purposes only, but could also be used, if required, to generate steam for the engine-room. They give a steam pressure of 80 lb. per square inch.

A locomotive boiler supplied by Beyer, Peacock and Co., Limited, supplies steam at a pressure of 200 lb. per square inch and gives 3000 lb. of steam per hour. Two

water-tube boilers, one of the Babcock type and the other a Niclausse, are also to be found here. The Babcock boiler contains its own superheater, and will give 100 deg. to 150 deg. Fah. of superheat. The Niclausse boiler works at a pressure of 200 lb. per square inch, and gives 8000 lb. of steam per hour. These three boilers supply steam to the engine. The installation is completed by a Schmidt gas fired superheater, which is capable of taking 3200 lb. of steam at a pressure of 200 lb. and superheating to 700 deg. Fah.

The steam main is 6in. in diameter. and is carried along the engine-room wall in duplicate. It is so arranged that steam from any of the boilers can be admitted to any engine at will.

The gas engines which form part of the engine-room plant are supplied with gas by a 500 horse-power Mond producer, situated at the western end of the power station. It is of the non-ammonia recovery type, and is capable of gasifying 5 tons of coal per day, and of generating 30,000 cubic feet of gas per hour. The holder in connection with it supplies gas at about 3in. of water pressure to all parts of the building. Its capacity is 6000 cubic feet. This gas is used in the metallurgical laboratories for smelting purposes, in muffles, and for general heating purposes in the main buildings. This plant, in common with all the power station machinery, is adapted for experimental work, and several 30-hour tests have been performed on it by the students.

The engine-room is fitted up on the same principle as the other sections, namely, with a view of obtaining the maximum amount of teaching value, combined with practical efficiency for commercial working. The engines, therefore, are all of different patterns. The south-east corner is devoted to high-speed steam engines. Here we have a 100 B.H.P. compound Belliss engine (presented by the makers) coupled to a Bruce Peebles 110-volt D.C. generator, together with a Weir condensing plant on the dry air pump system. The next unit is a 30 B.H.P. De Laval turbine coupled to a compound-wound D.C. generator running at 2000 R.P.M. The last of the high-speed engines is a Willans 100 B.H.P. triple-expansion set of the well-known central valve type. This also was presented by the makers, and is connected to a Worthington condensing plant, with a Simplex air pump. The engine drives a four-pole Siemens direct-current generator, giving 110 volts. There are two specimens of medium speed engines. A 75-kilowatt marine engine, entirely self-contained, was supplied by Messrs. J. and H. MacLaren, of Leeds. It is a triple-expansion engine with flat valves of the trick-ported type, and drives a Westinghouse alternator which is capable of taking a permanent overload of 50 per cent. The only horizontal steam engine is a 50 indicated horse-power cross-compound Ruston Proctor set running at 200 revolutions per minute. It is coupled to a 30-kilowatt Westinghouse direct-current generator, wound for 440 volts; all the other direct-current generators give 110 volts. This is used in connection with the three-wire system, to be mentioned later. An air compressor capable of compressing 25 cubic feet of free air per minute to a pressure of 200 lb. is used in connection with the refrigerating plant, and for starting the gas engines. The gas engines include a Premier engine of the single-cylinder scavenging type, capable of giving 100 brake horse-power at a speed of 160 revolutions per minute, and a Westinghouse engine. The former is the only experimental engine in the station. All the others, while capable of being tested, are purely commercial engines, no provision being made for structural alterations in connection with experimental work. This engine, however, also takes its share of the load of the station, as it is direct coupled to a 55-kilowatt Westinghouse direct-current generator. The engine can be run with or without scavenging; quality, quantity, or hit-and-miss governing used at will; high and low-tension ignition are provided, and the cooling water to the different parts is kept separate, so that exhaustive trials under all conditions can be and have been made. The Westinghouse engine is of the well-known three-cylinder type. It is coupled direct to a 37½-kilowatt direct-current Westinghouse generator, and runs at 290 revolutions. The smaller engines include a 10 horse-power Diesel oil engine, which drives an ammonia compressor for the refrigerating plant, and three petrol motors —a 20 horse-power, four-cylinder Daimler, a three-line six cylinder Ariel Simplex, and a Rollason three-cylinder motor. For the latter a special motor testing bed is provided. A rotary converter of 37½ kilowatt capacity is used for converting alternate current to direct current, or *vice versâ*, for use in the buildings, while three Westinghouse single-phase transformers are also installed. The large switchboard contains a panel for each engine, and contains all the necessary instruments, meters, &c., for purposes of measurement and testing. The existing 110 volt system was, last year, found to be inconvenient for supplying the outlying buildings of the University. It was therefore decided to put down a 440-volt three-wire system to give light and power to these blocks. Accordingly a battery of 240 E.P.S. cells, with charging plant, has been installed in a small building near the power station. This system therefore, can be either worked directly by the Ruston Proctor engine, or from the battery. The load on the two halves of the system is equalised by a balancer, consisting of two 6-kilowatt machines mechanically coupled and connected across the outers. The middle point of the set is earthed through a resistance, so that if a fault occurs in one of the outers, work can be proceeded with until it is possible to shut down for repairs.

A 15 horse-power gas producer is also used for the purpose of short tests and experimental work. A laboratory, which is well provided with indicators, calorimeters, gas analysis apparatus, and all the necessary materials for engine and boiler testing, is adjacent to the boiler-room, and completes the mechanical engineering equipment.

The electrical engineering laboratories are very completely fitted up. The senior laboratory is 127ft. by 45ft. in size, and contains all kinds of electrical machinery. The fixed machines at the south end of this laboratory are designed to supply the different voltages required for experimental purposes. The supplies to the laboratory from the power station are 110 volts direct current and alternating current (3-phase) at 200 volts and 30 frequency. In addition, a battery of 112 E.P.S. cells gives a direct current supply of 220 volts and a low voltage battery supplies heavy currents at 2 to 25 volts. In these laboratories, therefore, direct current at 220 volts (200-250 ampères), 110 volts (150-200 ampères) and 2 to 25 volts (300-600 ampères), and 3-phase alternating current at 200 volts (50 frequency 25 kilowatts) and 200 volts (30 frequency 40 kilowatts) are available. The first three are supplied by the battery, regulated by a Thury booster, a rotary converter, with 3-phase auto transformer, and battery with plugboard respectively. The alternating current 50 frequency is given by the Brush 25-kilowatt alternator, and the 30 frequency supply by a Brown-Boveri machine. In addition to this there are motor generators by the British Thomson-Houston Company, and W. H. Allen, Son and Co., Ld., of Bedford. A recent installation is the 30-kilowatt motor alternator by Messrs. Holmes, of Newcastle, which gives a variable frequency from 50 to 20, and whose exciting winding is in halves to facilitate the conduct of a Behrend test. The remaining fixed set of machines consists of two motors and two alternators in line by Messrs. Parker, of Wolverhampton. The alternators are of the two-phase type, and are coupled to the motors by magnetic clutches. The motor testing beds are provided with motors of all kinds. They are fitted up for brake and torque tests, while grouping of machines for special experimental work is facilitated by the provision of an overhead crane. Among the special machines are:—A Brush tramway motor with controller and starter, Siemens crane motor, Winter-Eichberg single-phase commutator motor, Déri single-phase commutator motor, and Rosenberg constant-current train-lighting dynamo. An interesting machine at present in this department is an Edison Z type dynamo dated 1881, which was used for lighting the exhibition at the Crystal Palace in 1882, and has since been in constant use for twenty years. The installation is completed by a numerous variety of small motors, both direct-current and alternating-current, motor generators, transformers, and other small apparatus. A workshop adjacent to the laboratory is well provided with tools for making electrical machinery, and much of the smaller apparatus is made there. The junior electrical laboratory is on the upper floor, and is fitted up for instrument and meter testing, and all elementary electrical work. There are also galvanometer rooms, a photometric bench for glow lamps, an arc lamp photometer, a standardising room for rapidly correcting any electrical instrument, a drawing-office, and all facilities for capacity and high-tension work. As an illustration of the practical scale upon which all this work is performed, it may be mentioned that a cable ¼-mile in length is sunk in the ground for the performance of tests on the capacity of a three-core cable. The show cases in the junior laboratories contain loans of electrical apparatus and materials for the purpose of familiarising the student with the appearance of the various details mentioned in the lectures.

The remainder of block B is devoted to civil engineering, the whole of the lower floor being occupied by the hydraulic and strength of materials laboratory. The latter contains three machines for tensile, compression, and bending tests. The first is a 50-ton hydraulic tester of the Buckton type. It is worked by an accumulator, which is capable of giving a pressure of 2000 lb. per square inch. This machine will take specimens up to 8ft. in length. The next in size is a 100-ton Riehié vertical machine. This will take bending specimens up to 16ft. in length, whilst the position of the specimen makes tests of this description easy to carry out. The machine is driven by an electric motor, changes of speed being introduced by gearing and claw clutches, while the power is applied by means of vertical screws. The large 300-ton tester by Averys has been already described in these pages—see THE ENGINEER, May 21st, 1909. The smaller machines consist of a 10,000 inch-pound torsion tester of the well-known Avery type, an Izod impact machine by the same makers, and a Bailey hydraulic wire tester. Losses of power in transmission are experimentally determined by means of a set of experimental pulley blocks and a roller-bearing shaft. The chief object of interest in the hydraulic laboratory is an experimental tank, 30ft. high and 4ft. square. This is used for orifice experiments and for working the low-pressure turbines. The turbines are three in number:—A 2.8 horse-power inward flow vortex reaction turbine, an outward flow impulse Girard turbine, and an 8.8 horse-power Pelton wheel. The generation of power by these turbines can be measured by a Heenan and Froude water brake or a Morris and Lister eddy current brake. The pumps again are three in number; two centrifugal pumps giving 200 and 700 gallons per minute respectively, and one duplex differential pump with Guttermuth valves, which is capable of giving anything between 470 gallons per minute at a head of 75ft. and 156 gallons per minute at 250ft. The water is measured by two wrought iron measuring tanks, each 6ft. in diameter and 10ft. high. A 10in. valve is provided to empty one of these while the other is filling, the height of water in each being observed by a gauge glass. Kent and Venturi water meters are also provided for measuring purposes. An experimental pipe line is designed to take pipes of any diameter up to 6in., while pressure measurements are made by connecting to differential gauges on the wall. The water raised by the pumps circulates through this pipe line to the small channel, which is about 2ft. wide, and in which weirs are fitted for experimental work. The larger experiments, involving the flow of water in channels, will, however, be done in the new experimental channel outside. This has a length of 200ft., and in it experimental work on a practical scale will be possible. The remainder of this section consists of a large drawing-office, library, small applied mechanics' laboratory, and cement testing room. A small building in the courtyard is also fitted up for cement and reinforced concrete work.

The training of the engineering student is by no means confined to these three departments. Besides these he has to take physics, chemistry, accounting, mathematics, and metallurgy or geology. The metallurgical department is equally well fitted up, and has been at work for two or three years, while the physics and chemistry departments are just finished, so that now the whole of the engineering training will be received at Bournbrook. The workshop, laboratory and drawing-office training form exceedingly important parts of the student's curriculum, and to these the bulk of his time is given. Many of the students spend their summer vacation in a works, in order to obtain further practical experience, so that on leaving the University their knowledge is not at all limited to theory, but their theoretical ideas are enriched by the practical training received.

RECENT DEVELOPMENTS IN QUICK-FIRING FIELD GUNS.

THE advent of the small-bore magazine rifle, with its greatly increased range and volume of fire, rendered it necessary to develop a gun capable of keeping the rifleman at a distance. So long as a gun had to be run forward by hand after each round it was capable only of a slow rate of fire, and the gunners were exposed to the enemy's rifles while running the gun up, even if a shield was provided. It was at first attempted to increase the rate of fire and to reduce the exposure of the detachment by providing the gun-carriage with a spring spade, which dug into the ground; when the carriage recoiled, it compressed the spring, which then drove the carriage forward again. This system did not materially increase the rate of fire, since the gun had to be re-layed after each round. It was superseded by the modern equipment, in which the carriage stands steady while the gun itself recoils.

The French field gun, the pioneer of existing types, appeared in 1898. In it the carriage is held by a spade on the trail and brakes on the wheels. The gun itself runs back on a cradle for a distance of 44in., the recoil being absorbed by the friction of the hydraulic buffer. This is a cylinder filled with glycerine, in which works a piston attached to the gun. On recoil the glycerine is forced through narrow orifices into a reservoir of compressed air; when the gun has come to a standstill the expansion of the air drives back the glycerine and returns the gun to the firing position. Simple as this gear sounds, the construction proved complicated. Special valves and movable partitions had to be introduced to prevent the glycerine from mixing to a froth with the air. So many difficulties were encountered, that this construction is never likely to be repeated. It was improved upon some years later by Messrs. Schneider. In the Schneider equipment the gun is run up by a separate piston and compressed air cylinder, and the buffer is similar to the German type described below.

Side by side with the compressed air, or hydro-pneumatic gun, the German type was developed by Ehrhardt, and afterwards by Krupp. In this design the graduated resistance which absorbs the recoil is obtained by forcing the buffer-liquid past the piston through open channels in the inner wall of the cylinder. The gun is returned to the firing position by a column of helical springs surrounding the buffer cylinder.

These two main types, the French and the German, have persisted, with slight modifications, to the present day, and all existing field gun equipments are built upon one or the other of these systems. Several new inventions have since appeared, embodying radical alterations in the recoil gear. Most of these have been found suitable for special natures of guns, such as mountain guns or howitzers. But none of them have succeeded in superseding the French and German systems of the beginning of this century.

Before considering these novel systems, it will be well to deal with the later modifications of the German or helical spring gear. The French gear, since its improvement by Schneider, has remained practically unaltered. The first difficulty met with in spring equipments was the liability of the springs to break or collapse on recoil. Given a column of springs 6ft. long and a recoil of 4ft., the column has to be compressed into a length of 2ft. at every shot. In order to afford the initial compression necessary to run up the gun when firing with elevation, the column must originally be about 8ft. long. This entails a degree of compression much greater than is admissible in ordinary engineering practice. In the English guns the difficulty has been got over by the use of the Armstrong telescopic spring case. This has an inner and an outer column of springs separated by an intermediate casing. On recoil the inner spring is compressed between the shoulder of the buffer, which recoils with the gun, and the inner shoulder of the casing. The outer spring is compressed between the outer shoulder of the casing and the end of the spring-case, which is fixed to the cradle. If the gun recoils 4ft. the intermediate casing is pressed back 2ft., or until the compression of the inner and outer springs is equal. This gear divides the compression between the two columns of springs, and so saves them from being crushed.

The German makers have overcome the difficulty by more simple means. The initial compression is reduced to a minimum by using a valve which allows the buffer-liquid to pass freely during the run-up, thus eliminating the buffer resistance. This enables slender springs of flat section to be used, which suffer less from compression These springs are made of very high-grade steel, the Krupp specification being:—Yield, 89 tons per square inch; break, 137 tons (treated).

The first important modification of the hydraulic

buffer was the Ehrhardt-Vavasseur controlled recoil gear. Instead of obtaining the graduated resistance to recoil by forcing the liquid past the piston, the liquid passes through ports in the piston itself. These ports are gradually opened and closed by disc valves, which are rotated by rifled grooves in the buffer-cylinder. The two disc valves are capable of longitudinal motion along the piston-rod, so that only one is in action at a time, namely, the one which is pressed against the front or the back of the piston, according to the direction of motion. Thus during recoil the front valve only is in action, the rear valve being half an inch clear of the back of the piston. So far, this is in effect the old Vavasseur gear employed in British heavy gun mountings of thirty years ago. Messrs. Ehrhardt have further developed this gear by connecting the piston-rod to the carriage, so that the piston is rotated as the gun is elevated. Thus at high elevations the cut-off begins earlier in the recoil stroke, so that the resistance is increased and the recoil shortened, while the same motion causes the cut-off of the running-up valve to commence later, so that the run-up is eased in proportion to the height through which the weight of the gun has to be lifted by the springs or compressed air. Both Messrs. Ehrhardt and the Bethlehem (U.S.A.) Ordnance Factory have made field guns on this principle, but the system has never found favour for field guns, although Messrs. Krupp use a Vavasseur valve in the piston to control the action of the running-up valve mentioned above. For howitzers and mountain guns, in which it is difficult to find room for recoil at high elevations without the breech striking the ground, the controlled recoil system has been freely adopted. Thus the 1909 Schneider 4.2in. field howitzer has controlled recoil, with this difference, that the rotation of the piston takes place only at angles of elevation over 30 deg.

The objection to the Vavasseur-Ehrhardt system is that its action is liable to be affected by wear of the transmission gear which connects the piston to the carriage. A small amount of wear or play may cause a difference of $\frac{1}{16}$in. in the opening of the valve, which again makes a difference of several inches in the recoil.

The principal rival of the controlled recoil system for howitzers is the Krupp rear trunnion system. In this the cradle trunnions are at or behind the breech of the howitzer, so that when the howitzer is elevated its breech comes no nearer to the ground, and there is still plenty of room for recoil. The forward preponderance is supported by a balance spring. It is objected to this system that at high elevations the centre of gravity is above the top of the wheels, causing unsteadiness of the carriage on bad or sloping ground; further that the howitzer is less firmly supported than with central trunnions, and that this is a source of inaccuracy. Equipments on this system have been supplied by Krupps to Switzerland and Japan.

Several other devices have been invented with the idea of obtaining long recoil in howitzers at all angles of elevation. Armstrongs have patented a howitzer with swinging recoil. In this the cradle is hung from trunnions which are above the axis of the piece. After the howitzer has recoiled a few inches the cradle is disengaged from the elevating gear and left free to swing about the trunnions. The result is that the breech of the recoiling howitzer swings backwards and upwards instead of straight downwards. Schneiders have patented a similar device, in which the howitzer and cradle swing on an imaginary pivot, along curved guides struck from a centre above the axis of the piece. Neither of these inventions has been developed beyond the experimental stage. Schneiders have another device, in which the axletree is normally cranked downwards, but is revolved so as to bring the crank upwards when firing at high elevations, thus affording more room for recoil. This gear is found too heavy for field howitzers, but has found a useful application in mountain guns and mountain howitzers, where the weight to be lifted is small.

The Rothe recoil gear for howitzers has been recently patented in Germany. The object of this is to obtain controlled recoil without the complication of piston valves. The buffer cylinder is considerably longer than the recoil stroke, and the windage for the passage of the buffer-liquid past the piston varies at different points of the cylinder. When it is desired to shorten the recoil for firing at high angles, the piston is drawn forward into the narrower part of the cylinder by a screw working in the hollow piston-rod. At the same time a movable partition in the cradle is screwed forward against the running-up springs, increasing their initial compression and lifting power. These motions are obtained by somewhat elaborate transmission gear connected to the elevating wheel, and it is doubtful whether the extra complication thus introduced compensates for the abolition of the piston valves.

Differential recoil gear.—This gear is intended to decrease the recoil energy of a Q.F. gun or howitzer, and so enable a stable carriage to be obtained with less weight, or a gun of greater power to be fired from the same carriage without unsteadiness. Before firing the gun for the first time, it is hauled back by a winch against the springs to the extreme recoil position, loaded, layed, and released. The gun then flies forward under the action of the springs, and is fired by a tripper as it reaches the forward position. The resultant recoil velocity is then equal to the difference between the normal recoil velocity and the forward velocity imparted by the springs. On recoil the gun is held in the rear position by a catch, and is ready to fire again. If the whole of the recoil be taken on the springs, eliminating the hydraulic buffer altogether, the recoil energy—neglecting loss of efficiency from friction—is reduced to one-quarter of the normal amount. The explanation of this is as follows:—In a field gun of ordinary Q.F. construction the powder pressure acts on the gun, driving it backwards, until the pressure is relieved by the shell leaving the muzzle, which takes place after about .008 of a second. The acceleration due to the powder-pressure produces a recoil velocity of, say, 30 foot-seconds during this period, or 15 foot-seconds in half the period, namely, .004 second. Now, let the gun, before firing, be drawn back against the springs, so that the spring pressure is sufficient to impart a forward velocity of 15 foot-seconds to it, and let it then be released and allowed to fire. Then for the last .004 second of run-up the powder pressure will be overcoming the forward velocity of 15 foot-seconds, and for the first .004 second of recoil it will be imparting a rearward velocity of 15 foot-seconds to the gun, so that it will recoil to the point from which it started. If the weight of the gun be 10 cwt., then the normal recoil energy will be $\frac{30^2}{2g \times 2}$, or 7 foot-tons, and the recoil energy with differential gear will be $\frac{15^2}{2g \times 2}$, or 1.75 foot-tons.

The objections to the differential gear are, first, that if the gun misses fire it will overturn on to its muzzle; secondly, that the vibration due to the action of the springs during the run-up affects the accuracy of the shooting. The first may be got over by keeping the gun low down on the axletree, or using a cranked axletree; and providing a forward buffer to stop the gun; the second objection appears insuperable so long as springs are used, and practically limits the system to compressed air equipments. Most of the foreign gun-makers have constructed experimental field guns on the differential system, but the only guns which have appeared are the French Ducrest mountain gun—successfully tried in 1907—a Krupp Q.F. mountain gun, and the Krupp balloon gun described in THE ENGINEER of May 14th.

Pneumatic recoil gear.—Colonel Deport, the inventor of the differential recoil gear, has lately produced a gun in which the hydraulic buffer is replaced by a compressed air buffer, which also serves to run the gun up. Provided that the orifices through which the air has to flow during the recoil stroke are suitably narrowed, there is no reason why compressed air should not be employed instead of oil or glycerine.

The action of the Deport buffer is illustrated in Figs. 1 to 3. It consists of a cylinder A, containing air at 35 atmospheres, into which the piston B is forced on recoil. The piston is a sliding fit in the cylinder, and on recoil the air has to pass from one side of the piston to the other through the hole L in the plunger F, thence through the hollow of the plunger to the interior of the hollow piston-rod C, thence down the outside of the plunger by the groove F—Fig. 3—and so through the channel H to the other side of the piston.

When the recoil is completed, the pressure of the air

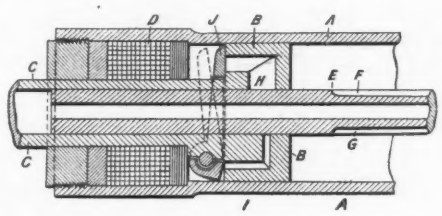


Fig. 3—DEPORT VALVE

on either side of the piston will be equal, and the force tending to drive the piston out, and so return the gun to the firing position, will be that due to the unbalanced area of the piston-rod.

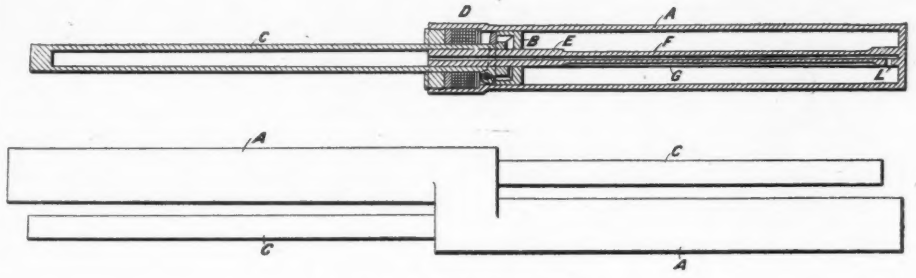
During the run-up the air has to return to the other side of the piston. Since, however, the run-up must be kept comparatively slow in order not to displace the carriage by the gun running up too violently, a separate channel I—Fig. 3—and groove G are provided for the return of the air. The channel H is closed during the run-up by the valve J, which is pressed against the mouth of the channel partly by the air pressure and partly by its own inertia.

The inherent defect of compressed air recoil gear—not running-up gear—lies in the variable resistance. For the air in the cylinder, unlike the oil or glycerine in a hydraulic buffer, yields at first by elastic compression, and the piston has to travel a certain distance before the opposing air pressure balances the thrust due to the recoiling gun, and has to be relieved by the air escaping through the air channels in the piston. Hence a buffer on this system has to be from 6in. to 12in. longer than a hydraulic buffer, according to its sectional area, and to the initial compression of the air. On the other hand, the preliminary period of slight resistance makes the action of the gear smooth and easy, and allows the shell to escape from the muzzle before the vibration of the carriage, under the thrust of the buffer piston, begins to make itself felt.

In the Deport gun it was found necessary, for the above reason, to provide for a recoil of 5ft. A piston-rod of this length would, however, be liable to bend unless made unduly massive, and the buffer has accordingly been made double-ended, as in Fig. 2, the stroke of each piston being 2½ft. The right-hand end of one piston is attached to the gun under the muzzle, and the left-hand end of the other piston to the rear of the cradle. The body A A of the buffer recoils on guides within the cradle to a distance equal to half the recoil of the gun.

The Deport recoil gear gives a simple carriage with a short and light cradle. The practical objection which has so far stood in the way of its adoption is the use of compressed air at 35 atmospheres, which has direct access to the piston glands. In equipments in which compressed air is used to run the gun up, the running-up cylinder itself is filled with glycerine, and the air is contained in a separate reservoir into which the glycerine is forced on recoil. But in a purely pneumatic buffer the presence of liquid in the cylinder would interfere with its correct action.

The principal advantage of the Deport gear is the lightness of the carriage. Thus the Deport guns exhibited



Figs. 1 and 2—DEPORT BUFFER

by the Forges de Châtillon at the Franco-British Exhibition in 1908 weighed only 19.5 cwt. with shield, though of the same power as the 18-pounder, which is 4½ cwt. heavier.

Construction of guns.—Very little progress has been made in this direction since the first Q.F. guns appeared. There is no advantage in lightening the gun itself, since this increases the recoil energy and requires heavier recoil gear. The wire-wound system is not used except in England. Foreign guns are rifled with a twist increasing from 1 turn in 25 calibres to 1 in 50 at the muzzle. This imparts the stress of rotation to the shell more gradually, and allows of the use of shell with thinner walls and containing a larger percentage of bullets then when a uniform twist is used. The latter is preferred in England as causing less friction in the bore, and giving a somewhat higher velocity. The breech mechanisms used are the wedge in Germany, the excentric screw in France, and the swinging block in England; these are all now made as single-motion actions. They are sometimes made as semi-automatic actions.

The principle of these is as follows:—In wedge and swinging block mechanisms the breech is opened and closed by the rotation of a spindle, actuated by the motion of a hand-lever fixed to it. In semi-automatic mechanisms this spindle is set parallel to the axis of the gun, and is extended forward to a length somewhat greater than that of the recoil stroke. A screw with a pitch of about one turn in 6ft. is formed on the spindle, which passes through a nut fixed to the cradle. During recoil the nut revolves freely; during the run-up the nut is held by a ratchet, and the spindle is rotated, throwing the breech open and ejecting the empty cartridge case. When the gun returns to the firing position the ratchet is thrown out of gear, and the breech would then be free to close under the pressure of a spring provided for this purpose, but that it is held in the open position by a catch connected with the extractor. When the next round of ammunition is inserted the extractor is pressed home, releasing the catch, and the breech closes under the action of the spring. An alternative method is to set the spindle in the usual vertical position, with a pinion on its lower end engaging with a rack formed on a rod attached to the gun and extending alongside the cradle. During recoil the rod is drawn back with the gun, and the pinion is not rotated; during run-up the rod is held by a tripper on the cradle, the rack rotates the pinion, and the breech is thrown open. When the gun returns to the firing position the tripper is pressed down, freeing the rack, and the breech is held open by the catch as before. Several equivalent mechanical devices are used. In all semi-automatic gears the breech is made to open during the run-up, since if opened during recoil the cartridge case would be thrown out so violently as to endanger the men behind the gun. In the Krupp semi-automatic guns the breech-block is set vertically, so that the loading opening is at the top instead of the side of the breech. These guns are easily capable of firing thirty rounds per minute, as against twenty with non-automatic gear.

The independent line of sight.—This was introduced in the French Q.F. gun in 1898. In one form of this the gun is mounted on an intermediate carriage to which the sights are attached. The sights are layed on the target by the laying number, and the elevation for the range is given with separate elevating gear by the elevating number, who stands on the other side of the gun. Various mechanical equivalents for the intermediate carriage are used; thus in the English equipments the sights are connected to the centre of a double-ended elevating screw. One end of the screw passes through a nut on the car-

riage, which is turned by the laying number; the other end through a nut on the cradle, turned by the elevating number. The Krupp triple elevating screw serves the same purpose.

Sights.—Most modern guns are fitted with the Goerz panorama sight. This is a vertical telescope with the eye-piece and object glass at right angles to its length. The object glass can be turned towards any point on the horizon without moving the eye-piece. The optical arrangement is shown in Fig. 4. The gable prism in the centre is connected by gearing to the revolving

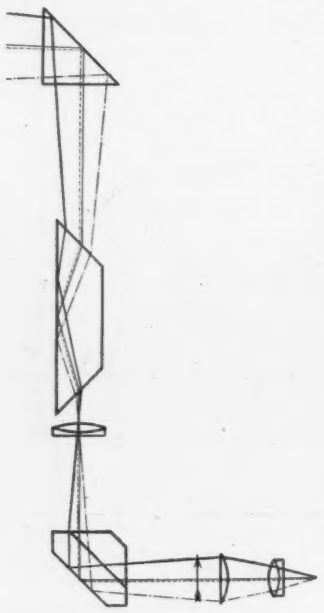


Fig. 4—GOERZ PANORAMA SIGHT

hood on top of the telescope, so as to revolve at half the rate of angular revolution. This keeps the image erect for all positions of the hood. The Zeiss "zigzag" telescope serves the same purpose as the panorama telescope. This is a straight horizontal telescope, with a reflecting prism in front of the object-glass. This prism can be turned into any one of three positions, in each of which the telescope commands an arc of 120 deg., so as to cover the whole circle.

Ammunition.—The modern field guns use fixed ammunition, fired by a percussion lock. High-explosive shell are filled with picric acid, ammonal, gun-cotton powder, or, more recently, trinitrotoluol. All these substances require a primer of fulminate of mercury to ensure detonation. Attempts to produce a good combined shrapnel and high explosive shell have so far proved fruitless. The best projectile of this nature is the Ehrhardt high-explosive shrapnel which is a shrapnel with a small charge—3½ ounces—of high explosive in the head, designed to improve the action of the shrapnel when burst on a gun shield.

Fig. 5 represents an Ehrhardt cellular ammunition wagon with jointed perch. This is tipped beside the gun, and the doors are opened outwards, forming shields for the detachment.

Description of illustrations.—Fig. 6 represents the

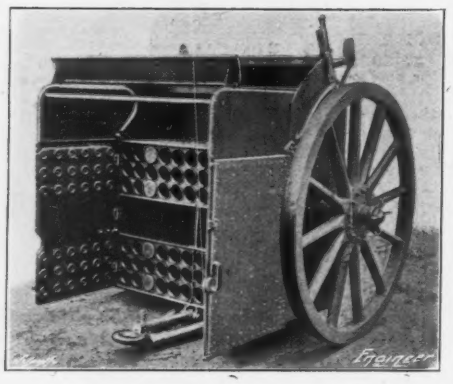


Fig. 5—EHRHARDT AMMUNITION WAGON

Schneider 75 mm. gun as supplied to Greece and Servia. The buffer, compressed air reservoir, and running-up cylinder may be noticed under the breech. These three cylinders are combined with one forging, which is fixed to the gun, and recoils with it.

Fig. 7—page 660—represents a 3in. gun by the Bethlehem Company. The special feature of this gun is that it has twin buffers, with the running-up springs inside them. It is claimed that working the springs in oil damps the vibrations and reduces the chance of breakage.

Fig. 8 represents the Austrian service 76 mm. field gun, with panorama sight. The cylindrical cradle, with guides on top of it, is seen under the gun. The breech mechanism lever is visible below the layer's left hand. The wheels are peculiar, having four bent felloes; four of the spokes fit into spoke-shoes at the junction of the felloes, while the remainder have tongues. The upper part of the shield folds down horizontally so as to give overhead cover.

Fig. 9 is a 75 mm. mountain gun by Vickers-Maxim, firing a 12½ lb. shell. The gun itself is in one piece, but the breech-ring and breech-block are removable, as the weight of the complete gun would be too great for one mule. The buffer is under the gun, and the twin columns of running-up springs are on either side of it. The panorama sight is visible on the left of the shield. The trail is in three parts, which fold together for convenience of pack transport.

REVISED RULES OF LLOYD'S REGISTER.

To many of our readers the announcement that the governing body of Lloyd's Register of Shipping have effected fundamental changes in their scantling rules will be of great interest. A large number of vessels, both at home and abroad, is every year constructed in accordance with these regulations, and they have had a considerable share in creating the modern practice of shipbuilding. On Thursday, the 17th inst., the General Committee gave their approval to the scheme, which will come into force, according to the usual practice, in six months' time, although owners may adopt the new rules at once if they so desire. Without going into the reasons in detail which have necessitated the changes, we shall contrast briefly the new system with the old one, with special reference to the technical aspect of the alterations.

One of the difficulties confronting any classification society is the fact that the scantlings must be known by the builder at the earliest possible moment. They must be capable of being fixed upon a knowledge of the chief dimensions of a ship. Some eminent naval architects have advocated the use of tonnage, or displacement, as a basis for fixing scantlings. But, although in the early days the scantlings of iron vessels were graduated on a basis of tonnage, no classification society to-day has ventured to adopt a standard so difficult to define in the early stages of a vessel's construction. The basis of the new rules is therefore on the same principle as the old, with some important differences.

The scantlings up to the present have been determined by two numbers, the first of which was compiled from the breadth and depth, and the second of which was the first number multiplied by the length of the vessel. Thus,

if B = Breadth moulded at mid-length (ft.)
D = Depth from keel to upper deck beams (ft.), with normal round up
G = Girth of midship frame (ft)
First Number = $\frac{1}{4}B + \frac{1}{4}G + D$
Second Number = $L(\frac{1}{4}B + \frac{1}{4}G + D)$

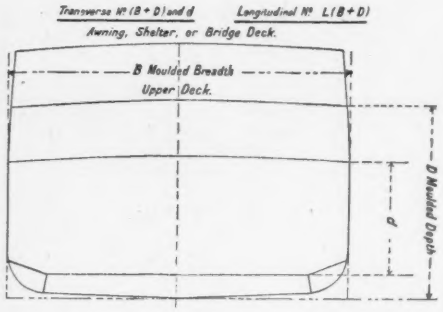
Some vessels obtained reductions from these in respect of special circumstances, but the above represents generally the method employed. The scantlings of frames, floors, thickness of bulkheads, &c., were governed by the first, and the thicknesses of shell plating, stringer plates, and deck plating were governed by the second, subject in some instances to some modification due to proportion of length to depth.

In the new rules the first number is more simply compiled than before, and consists of the sum of the moulded breadth and depth to upper deck. Thus:—

Transverse Number = (B + D)
Longitudinal Number = L (B + D),

D in this case being the moulded depth to the upper deck instead of the depth at the centre line, and L being the length between perpendiculars. On comparing the two sets of numbers we see that depth of ship does not bulk so largely in the new numbers as it did in the old, where it came in twice, and that the depth, as before stated, is moulded. The numbers are more easilyobtained, and, what is more important, they equalise the effect of variation of breadth or depth on the final result.

One of the first things to be done in getting out a midship section to Lloyd's Rules was to find out the



number of tiers of beams required to be fitted, for upon that, in conjunction with the first number, depended the framing scantlings. Additional tiers of beams were required to be fitted when certain definite limits of depth were exceeded. For example, vessels of 24ft. depth and under 32½ft. depth were required to have three tiers of beams. One disadvantage of this requirement was that at certain points, viz., the limits of depth referred to, a very substantial addition to the structure became necessary. The object of the requirement was, of course, to introduce additional support to the side as the depth increased, but it had the effect of localising that increased support at two or three places, instead of distributing it gradually. In the new rules this is completely changed, and, as shown on the sketch given above, the framing is made to depend on the transverse number, and also on the factor *d*, the height from top of floors to lowest deck at side. This now provides for a gradual increase of the framing, according as the transverse dimensions of the vessel are increased, and according as the depth *d* increases. Every vessel now will receive full consideration for the manner in which the side is supported, and if an owner wishes to lower a tier of beams below its normal position, subject to certain limitations, the result will be a reduction in the size of the frame, sufficient strength, of course, being supplied in the 'tween decks.

Another very important alteration made is in the manner of taking the depth for the proportion of length to depth. This is now the moulded depth, taken to the top of the continuous superstructure or long bridge, which may be fitted on the upper deck. The longitudinal number determines the thickness of the shell plating, and also, in conjunction with this proportion, the scantlings of the materials at the upper part of the structure. If the object is to obtain an idea of the proportions of the vessel as a girder, this is obviously the correct course, since these superstructures now are very strongly built, and are, to all intents and purposes, part of the vessel itself. A new Table is now introduced giving the complete requirements relating to water-tight bulkheads. As regards the number of bulkheads to be fitted, the requirements of the rules are substantially the same as before. But now the thickness of plating is made to depend on the total depth of the bulkhead above the tank top, and the sizes of the stiffeners are governed by this depth, associated with the length of the stiffener itself to the first point of support. It is quite a different system of construction from what was previously required, since the stiffeners are all vertical with no horizontal girders, and no vertical webs. It is, indeed, the system put forward in the Majority Report of the Bulkhead Commission. We must refer in a word to the other principal changes made. The most important of these is the expression of all thicknesses in decimal units, following the example of the Standards Committee. This is a change that was bound to come at some time or another, and, after the first unfamiliarity has been dispelled by use, will prove as useful to the naval designer and calculator as it has to others. The unit is simple itself, and leads to simplicity in work and practice. What will perhaps prove a greater stumbling-block in the shipyard are the small gradations of thickness employed—fiftieths of an inch = (0.02in.)—instead of twentieths (0.05in.). But this may also be got over by exercising a little care, and it need cause at the steel works no greater difficulty than is now experienced there in rolling boiler plates to sixty-fourths of an inch—a very common practice. Moreover, an advantage in the new unit is found in the fact that .02 of an inch is very nearly half a millimetre.

Following on the rules and regulations for ordinary steam vessels, there will also appear detailed requirements for the construction of oil vessels. Generally these tables are based upon those governing the scantlings of ordinary vessels, but additional requirements are made relating to the bulkheads in the oil tanks, &c. The web frame system is provided for throughout the oil tanks, as this system, with the stringers on the vessel's sides, works in admirably with the horizontal girders on the bulkhead, making a complete belt round the tank. There has been no provision made for deep framing, and this is perhaps a good thing, for, in addition to the absence of the advantage referred to above, the flexibility of these long frame girders requires serious consideration in deep vessels. The Committee also have provided for a maximum length of tank of 28ft., and for a maximum width of expansion trunk of half the breadth of the vessel, and these, together with the compulsory fitting of cofferdams at the ends of the oil spaces, are all very essential and justifiable regulations for the safety of the vessel. It is perhaps needless to say that the riveting requirements are considerably more stringent than in the ordinary rules.

WHAT IS A NEW INVENTION?

Of the many points which are continually cropping up in relation to letters patent, there is none more important to the would-be inventor than the question how far his experimental or other work, prior to his application, prevents him taking out a patent. This question is of particular importance to engineers who desire to take out patents for machinery, inasmuch as experiments often have to be carried out on a large scale and in such a manner that it is well-nigh impossible to avoid some kind of partial disclosure to a large number of persons. Finally, an inventor may find assistance absolutely necessary in order to perfect a design. Can he freely avail himself of proffered help without running the risk of "publishing" his invention? It is proposed to consider some of these questions as illustrated by various patent cases.

An invention must be new at the date when the patent is applied for. The invention must be new within the realm, that is within the United Kingdom and the Isle of Man. Publication before that date is, generally speaking, fatal to the grant. But what is publication? According to Mr. Swan in his "Law of Letters Patent":—"It is fatal to the validity of a patent if it is proved that the invention has been worked or used in public either by the inventor himself or by someone else prior to the date of patenting." But mere experimental use does not matter. The Haskell golf ball case affords a good illustration of these points. In that case, amongst a number of witnesses called to prove prior use, the most important was a certain Captain Stewart, who stated that nearly thirty years before the date of the plaintiff's patent he had made golf balls of wound rubber thread with a cover of gutta-percha. He had given away some to his friends, and sold some, and he had disclosed to at least one person the method of construction. He ceased to make this kind of ball in 1879 because it was not popular. Upon these facts the judge who first tried the case held that what Captain Stewart had done amounted to more than incomplete experimental use, and that it consequently invalidated the Haskell ball patent. He also pointed out that there is a considerable difference between the

experimental use of an invention by a patentee himself and by some person other than the patentee. For if the effect of the patent is to stop others from doing what they did before, even though the manufacture was only tentative, then it is clearly bad, inasmuch as it violates the express language of the Statute of Monopolies.

This decision in the Haskell ball case, which was ultimately affirmed by the House of Lords, is easy to understand and easy to remember. The Haskell ball was, as the facts turned out, an old invention, and could not therefore be the subject of a patent. It is also important as showing that mere use in public, but not necessarily by the public, is sufficient to invalidate a patent. In a much older case a patent for a lock was upset by evidence that a single lock of the same pattern had existed for several years upon a gate facing the public highway.

In Wood *v.* Zimmer I Holt, N.P., a patentee had sold the article in the public market four months before the date of the patent. Such sale was evidence of the invention having been used and exercised for the purposes of commerce, and not simply for the purpose of experiment, before the date of the letters patent. It was held that such use and exercise, and the subsequent obtaining a patent, were contrary to the whole spirit of the patent laws, which require a disclosure for the benefit of the public, whereas the secret might be lost to the public by such a course of proceedings. Further, it was pointed out that the patentee might thus have a monopoly for a much larger period than fourteen years, were he allowed to practise the invention in secret until there was a danger of its being discovered, or some other circumstances induced him to take out a patent.

It being thus clearly established that use in public amounts to publication, the next question for consideration is: Suppose the invention is of such a nature that a mere casual inspection does not disclose anything, or reveal the secret of construction in any way. Does this amount to publication? This point is practically decided by the "lock" case above considered. In that case the judge said:—"Public use means this: That the use of it shall not be secret but public, and in that sense I must say that if you think the lock used by Mr. Davies—the person alleged to have anticipated the patent—is a lock which combines the same thing, I think that is a public use of it, and is within the meaning of this clause of the Patent Act 'public use and exercise' as user in opposition to private and secret use. Therefore, if a man invents a thing for his own use, whether he sells it or not, if he invents a lock, and puts it on his own gate, and has used it for a dozen years, that is public use of it."

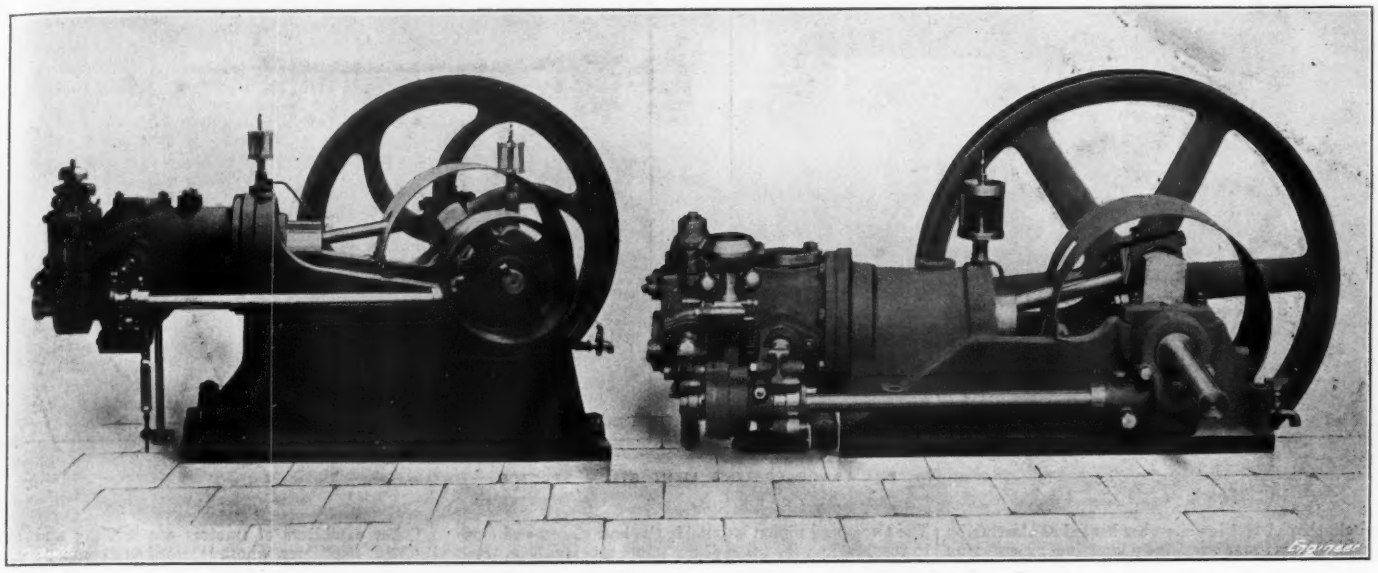
The following conclusion can be drawn from this case:—Suppose a man invented a new device to form part of an electrical machine, which device would be completely hidden from view. The fact that he sold one machine with the device would invalidate a subsequent patent, although it was not proved that anyone took the machine to pieces or discovered the nature or construction of the device alleged to be new.

It is interesting to go one step further, and consider how far publication of an invention which must be explained by the inventor if it is to be understood by anyone invalidates a patent. In Mr. Swan's work (above referred to) the following passage appears:—"If the article is such that the public can infer from inspection or analysis the process by which it is made, that will certainly constitute publication. But the article may be of such a character, *e.g.*, a high vacuum tube, that it supplies no clue to the method of manufacture. In such a case the process remains a secret, and, in the writer's opinion—no matter how much profit the inventor may have made—it is capable of being subsequently sold to the public in return for a fourteen years' monopoly."

There are certain kinds of prior use which certainly do not vitiate a patent. Thus, prior use by disclosure in confidence to the inventor's friends, or to workmen or assistants employed in working the invention, provided they are bound over to secrecy. Nevertheless, manufacture by a workman who is under no obligation of secrecy is undoubtedly publication, and will invalidate the patent subsequently obtained, unless the patentee can avail himself of the provision of the section of the Patent Act which enables him to oppose a grant to anyone who has stolen a patent from him.

Mere experimental use by a patentee does not constitute publication, unless, indeed, it be shown to have been profitable. It is obvious that there are some machines the utility of which cannot be tested except in public, and it would be hard upon a patentee to penalise him in such a case.

It is one thing to tell a patentee that he has lost his rights by an inadvertent publication; it is another to point out to him a method of putting himself right if he has inadvertently disclosed his invention. There is one method at least by which he may preserve his rights. Many inventions are in process of evolution. Some new device is constantly occurring to the mind of the inventor, something which gets rid of a superfluous part, or some rearrangement of existing parts, which renders the whole more valuable. Now, a patent may be upheld which relates to the combination of an old device with something new. In Spencer *v.* Jackson, Lord Westbury said:—"It is impossible to deny that, if there be a combination of several things previously well known, which combination is attended with results of such utility and advantage to the public that the combination itself is rightfully denominated a substantial improvement, it is, I say, impossible to deny that that is the subject of a patent." Supposing, therefore, an inventor were to think of something new and useful which he can use in combination with something already published, he may be able to retrieve his fortunes. In the well-known case of Thomson *v.* Batty, it was held that a new and successful combination of old parts of an old machine, so devised as to attain a desired improvement, viz., the reduction to a minimum of the errors arising from mechanical and magnetic causes, in the action of a mariner's compass, was good subject matter for a patent.



Figs. 1 and 2—FIELDING AND PLATT'S 2½ AND 7-H.P. LAMPLESS OIL ENGINES

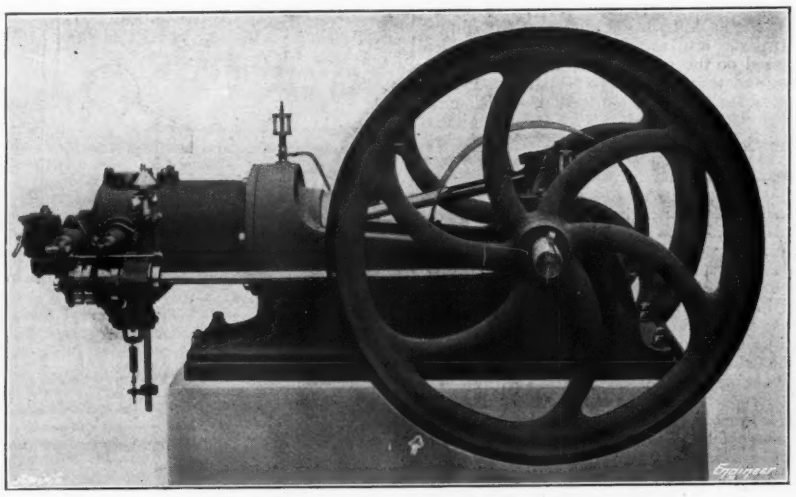


Fig. 3—FIELDING AND PLATT'S 24-H.P. SUCTION GAS ENGINE

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

THE seventieth annual show of the Royal Agricultural Society of England is being held this week in the ancient city of Gloucester, where it was opened on Tuesday last. The last occasion when the Society visited Gloucester was as long ago as 1853, and resulted in a financial loss of about £2000. In the early period of the Society's existence, however, losses were regarded by the officials with more equanimity than in recent years. In 1853 the number of implements entered was 1803, and the head of live stock 737. The statement of entries for the present show contrasts very markedly with its predecessor at Gloucester, the number of entries of live stock being 3734, and of produce 765, whilst the number of stands in the implement yard is 437, including nearly 5000 individual exhibits, and necessitates the employment of 12,886ft. of shedding. Although not a record entry, this represents over 800ft. more shedding than was required at Newcastle last year, and is only slightly less than that at Lincoln and Derby. It need scarcely be said that the space occupied is very largely in excess of that at the ill-fated Park Royal during the last two years of its existence as a showyard.

A better site could scarcely have been chosen for the show than the present one at Gloucester. It is a level expanse of over 100 acres on the south side of the Over Causeway, a portion of Alney Island known as Castle Meads, Oxleaze, and Portham, a large portion of which belongs to the Corporation. It is within easy reach of the centre of the city, and the two railway stations are closely connected by electric tramways, and with more settled weather than was experienced on the opening day, will no doubt prove as successful as the average show.

The Society offers for competition its usual silver medals, and competitions have also been held for fruit tree spraying appliances, for which money prizes are offered. In addition the Society has arranged a competition for hop-drying plants, which, however, cannot, of course, be decided until the crops are ready in the autumn. The contents of the implement yard from year to year bear a striking resemblance to each other, but this year the visitor cannot help being struck by the further increase in the number of exhibits of light traction engines and oil engine driven vehicles suitable for farm and estate work. The builders of the heavier classes of road engines are taking up the lighter forms of machine much more seriously than formerly. Wind engines are also very conspicuous, while the display of purely agricultural implements is well up to the average.

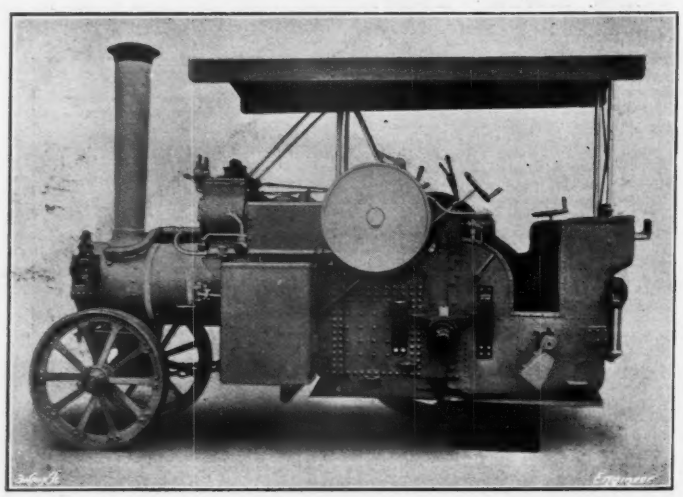
Amongst the exhibits of oil engines the stand of Blackstone and Co., Stamford, provides one of the most attractive features. This firm exhibits a four-cylinder vertical marine engine which works on the Otto cycle, but in which the fuel is injected under pressure somewhat on the lines of another well-known type. A noteworthy feature of this engine is that by a simple longitudinal movement of the cam shaft the engine can be reversed instantly, which makes it suitable for marine

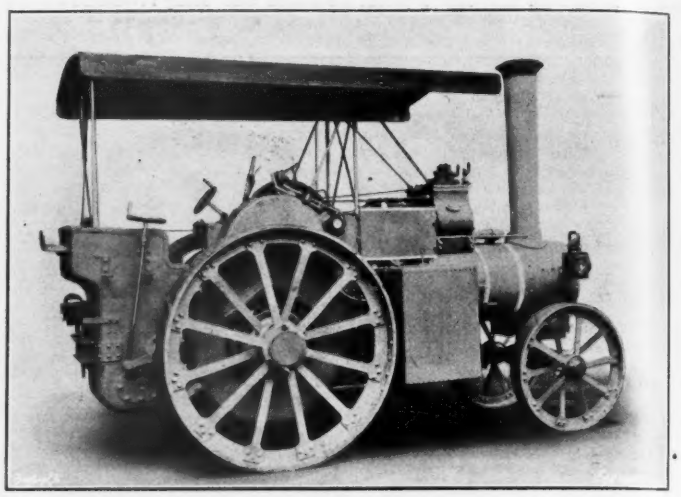
work. We are informed that it has already been fitted to several fishing boats with successful results. The compression of the charge is comparatively low, and the fuel is injected into the cylinder at or near the end of the compression stroke by air compressed to 400 lb. per square inch. As a very high compression is necessary to raise air to a temperature sufficient to ignite the crude oils on which the engine runs, additional means have to be provided to ignite the charge. In this engine a dual spraying device is used. It consists of a main jet adapted to deliver its charge into the combustion chamber and an auxiliary nozzle delivering a small jet into a bulb-shaped ignition chamber heated at starting by means of a lamp, and afterwards kept incandescent by the combustion of the fuel. The ignition chamber communicates with the combustion chamber by a port, so arranged that the flame produced in the ignition chamber impinges upon and ignites the main fuel spray in the combustion space. The oil is delivered from a tank to the spraying device by a pump controlled by a governor, and first reaches the auxiliary spray, all oil in excess of the quantity required for this overflowing into the main spray. This ensures a charge being injected at every cycle, thus keeping the engine hot when running either light or loaded. The air compressor is operated by an excentric on the crank shaft. The initial pressure of explosion is prolonged to give an indicator curve resembling somewhat that of a steam engine, by injecting a further supply of fuel into the combustion chamber as the working stroke proceeds. A single-cylinder horizontal engine designed to work on the same principle is shown on the stand in operation.

Fielding and Platt, Limited, Gloucester, have a good display of engines of their most recent design, including a 24 brake horse-power suction gas engine, which is shown on Messrs. Marsden's stand driving a stone-breaker. This engine—Fig. 3—is conspicuously simple, and its vital parts are accessible. The low-tension magneto is placed on the opposite side of the engine to the valve gear, and the valves are specially get-at-able. An oil tray round the bed, ring lubrication, and balanced crank are other features of note. The cylinder dimensions are 9½in. by 18in. The 2½ horse-power lampless oil engine is shown in Fig. 2. It is shown driving a three-throw pump direct, and has water injection. Small plants of this description have found favour for irrigation purposes in India. A third engine, Fig. 2, shown by this Gloucester firm is an inexpensive 7 horse-power lampless oil engine with cylinder 6½in. by 10in. The crank-pin lubrication is continuous, and sight-feed lubricators are fitted to other parts. A water injection system is provided, and in order to keep the vaporiser up to the necessary temperature, besides the heat of explosion, that produced by the exhaust is passed round it.

Amongst the exhibits of heavy motor vehicles the light steam tractor shown by Wm. Foster and Co., Limited, Lincoln, calls for particular mention on account of the new spring gear system which is embodied in the design. The illustrations—Figs. 4 to 7—given herewith will enable readers to understand the principle on which the suspension of the tractor depends. It differs materially from the method hitherto adopted in this class of engine by the same makers, inasmuch as the compensating levers and pins formerly used have now been discarded. The cylinders are 4½in. and 6¾in. in diameter by 9in. stroke, and are bolted to a planed seating riveted to the boiler, no bolts penetrating through into the steam space. The boiler is constructed to carry a pressure of 210 lb. per square inch, and the stop valve is arranged on the top of the cylinder, the passage from the boiler to the stop valve and safety valve forming a steam jacket. D slide valves are used, and the valve gear is of the Stephenson link type. The fly-wheel is 2ft. 7in. diameter by 3½ft. wide, turned and faced on the edges, and the crank shaft is forged out of solid mild steel, with main bearings 2½in. diameter and 3¾in. long. For driving the two-speed pinions four keys are forged with the shaft and machined out of the solid. The crank brackets are of cast steel with adjustable brasses, are secured to the hornplates by bolts, and the intermediate shaft is of mild steel 2¾in. diameter. The hind axle is also of mild steel, 4in. diameter, and the axle-boxes are of cast steel machined to receive the axle bearings. The external position of these boxes is shown in the transverse section to give a very broad and stable base for the spring-supported structure. The triangle indicated is drawn with the centre of gravity of the engine as the apex and the sides of the triangle intersecting the centre lines of the spring buckles. By carrying down the sides of the triangle to the ground level an effective base line of over 8ft. results. In this manner the abolition of the compensating levers hitherto used is effected, while with unit dimension the strength of the rear axle is increased and superior bearing surface made possible. In addition, both road wheels are driven direct. The gearing provides two road speeds, namely, three and six miles per hour with the engine running at normal speed, and is of machine-cut crucible cast steel. The two-speed pinion is outside the hornplates, and close to the bearing, the teeth of the pinions being 1¼in. pitch and 1¼in. wide; they are moved in and out of gear by two levers so that only one pinion is in gear at once. The intermediate wheel has teeth 1¼in. pitch, and 1¾in. wide, and is secured to the intermediate shaft by steel keys. The intermediate pinion with shroud has teeth 2in. pitch by 2¼in. wide, and is also secured by steel keys. The spur ring for the hind axle with shroud has 2in. pitch teeth, and these are 2¼in. wide. The ring is secured to a cast iron centre by bolts. Differential gear is provided, and this can be locked from the outside of one of the road wheels when desired, so that both wheels will revolve with the axle. The driving wheels are 5ft. 2in. diameter by 9in. wide, and are constructed to comply with the Light Locomotives Act. The fore travelling wheels are 3ft. 2in. diameter by 5in. wide, and the axle is supported on a transverse laminated spring bearing on the carriage. The steering is of the usual traction engine type, and there is a feed-water heater capable of raising the temperature of the feed to about 180 deg. Fah.

We have had an opportunity of witnessing the working of this engine hauling a trailer carrying five tons on give-and-take roads round Lincoln, and the system of spring suspension appeared to be quite successful. By taking note of the distance between the top of the near side road wheel and the boss of the engine fly-wheel, it could be observed that the vertical space scarcely varied at all, thereby demonstrating the easy running of the engine and keeping a rolling contact between the pitch circles of the driving pinion and the intermediate wheel within a fraction of an inch. The boiler steamed freely, and the engine had no difficulty in taking its load up hills of average severity.





Figs. 4 and 5—FOSTER'S LIGHT STEAM TRACTOR

Other exhibitors of tractors are Aveling and Porter, Limited, Rochester, whose tractor has a compound engine and Belpaire fire-box; Chas. Burrell and Sons, Thetford; Clayton and Co. (Huddersfield), Limited; Clayton and Shuttleworth, Limited, Lincoln; the Cyclone Agricultural Tractor Company, Limited, 80, Moorgate-street, London; Fodens, Limited, Sandbach; John Fowler and Co., Limited, Leeds; Richard Garrett and Sons, Limited, Leiston; Ivel Agricultural Motors, Limited; Leyland Motors, Limited, Leyland; Mann's Patent Steam Cart and Wagon Company, Limited, Leeds; Marshall, Sons and Co., Limited, Gainsborough; Ransomes, Sims and Jefferies, Limited; Robey and Co., Limited, Lincoln; H. P. Saunderson and Co., Bedford; Savage Bros., Limited; W. Tasker and Sons, Limited, Andover; Wallis and Steevens, Limited, Basingstoke; and the Yorkshire Steam Wagon Company, Limited, Leeds. Mann's Patent Steam Cart and Wagon Company, Limited, shows for the first time a compound 5-ton steam tractor, with cylinders 4in. and 6¾in. by 8in., which embodies one or two features of note. It is a four-shaft tractor, and the engine is fitted with link valve motion and a device for admitting high-

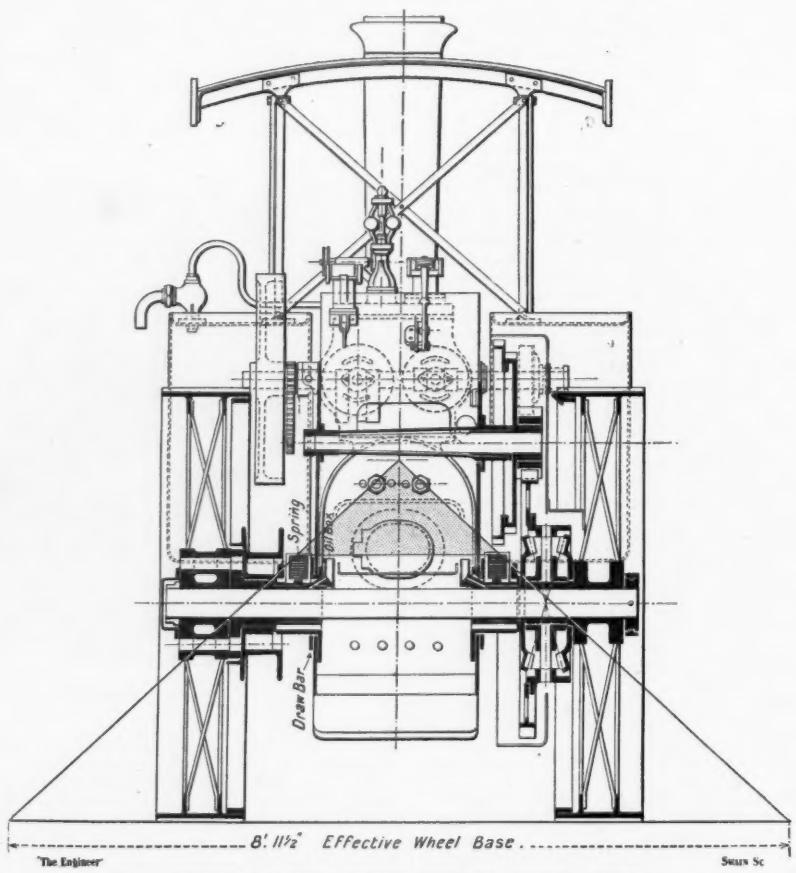


Fig. 6—FOSTER'S TRACTOR—SECTION THROUGH DRIVING WHEELS

pressure steam to both cylinders and exhausting separately. A lever for locking the differential gear when necessary is reachable from the platform. Perhaps the most remarkable feature of the engine, however, is the arrangement of spring gear, which is designed so as to keep the pitch circles of the intermediate and axle gears always in rolling contact. To this end the intermediate shaft and main axle are carried on one side in a solid bracket, and at the opposite end the intermediate shaft is supported in a trunnion bearing to give the necessary movement. The next train of gearing is mounted on the end of the shaft nearest to the trunnion bearing, where the movement being so close to the trunnion, is a very small fraction of the total movement of the main axle spring. The engine is fitted with a handy screw brake for the trailer.

Leyland Motors, Limited, Leyland, show two forms of heavy motor vehicle, one driven by a four-cylinder petrol engine, and the other by their well-known steam system. The latter is built with a large steel cylindrical tank, and has been specially designed for pumping purposes. The air from the cylinder is exhausted by a steam ejector fitted on the boiler, and the vacuum thus created may be utilised for lifting liquids into the cylinder, which has suitable outlets through which the liquids can be discharged. In case the liquid is laden with solid matter a propeller is fixed in the bottom of the cylinder. It is operated by gearing from the engine. Richard Garrett and Sons, Limited, Leiston, show a steam tractor of their standard pattern, a portable engine with superheater, and a 5-ton steam wagon of special design, which we hope to illustrate and describe in a future issue. It may, however, be stated here that although its general appearance is familiar, the method of connecting the main channel frame to the front end of the barrel of the locomotive boiler is original, and should allow freedom for both expansion of the boiler and a certain amount of torsional stress without setting up strains in the boiler.

guarantee for the compound drop valve engine a consumption at 160 lb. pressure and 500 deg. Fah. = 12·5 lb. per indicated horse-power condensing.

John Fowler and Co. (Leeds), Limited, have an exhibit which is illustrative of the various manufactures produced at the Leeds works. The most prominent feature is a compound Class B 4 ploughing engine designed for the familiar double-engine system of steam cultivation for which this firm is world famous. This engine is fitted with a high-speed governor and equilibrium throttle valve, so that it is equally adaptable for thrashing, sawing, pumping, &c. A double-speed gear is provided for the ploughing motion, and this is fitted with a special clutch by means of which both sets of gears are controlled by one hand lever, making it impossible for both sets of gears to be in engagement simultaneously. The hind wheels are 6ft. diameter by 20in. wide. The boiler is designed for 180 lb. pressure, and has a pressed steel manhole cover. Other examples of pressing and flanging noticeable on the engine are the hind tank, ash-pan, gear covers, &c. Provision is made for easy cleaning and lubrication. The ploughing set is completed by the exhibit of a six-furrow anti-balance plough. An improved compound spring-mounted road locomotive is exhibited in which high-pressure steam can be admitted when when necessary into the low-pressure steam chest by an automatically closing starting valve. This engine has an improved third-speed road gear and safety clutch. The features of this gear are the provision of a central adjustable suspension bolt and equalising levers, which ensure the driving gear running constantly in true pitch. The locking arrangement for the differential gear is worth mention. When using the winding drum the driving pins at each side of the engine are removed, and the differential gear locked from the footplate; the winding drum then revolves at the same speed as the road wheels. By leaving the pins in on the differential side and unlocking the gear the drum will revolve at double the speed of the

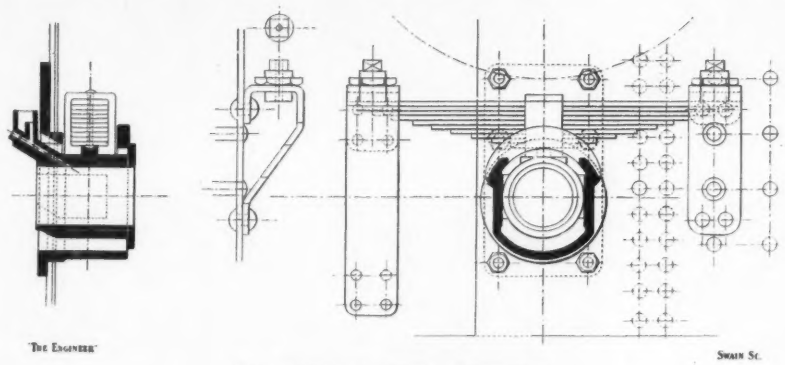


Fig. 7—FOSTER'S SPRING SUSPENSION

Marshall, Sons and Co., Limited, Gainsborough, have on exhibition, amongst other of their well-known productions, an agricultural oil motor, which is substantially built and likely to be serviceable for all kinds of farm work, such as ploughing, cultivating, hauling, &c. It has two vertical cylinders 7in. by 7in., and the carburetter is designed to enable the engine to run on paraffin. The engine is provided with ample means for cooling, has a low-tension magneto, and the framework and gearing are of a substantial nature. Three road speeds—two, four, and six miles—are provided, and there is a winding drum. The engine gives 30 actual horse-power at 860 revolutions per minute. The hind wheels are built up, and a driving pulley is fitted on the end of the crank shaft, suitably placed for driving any machinery by a belt. This tractor has a really substantial appearance. We shall deal with other motor vehicles in our next issue.

Robey and Co., Limited, Lincoln, are represented by various types of engines, including a single-cylinder horizontal fixed engine with automatic drop valve gear, which is both simple and effective, and a compound portable engine with neat and compact arrangement of jet condenser, which has been described in THE ENGINEER, July 17th, 1908. The boiler of this engine is fitted with the firm's improved fire-box roof stays, by means of which the stresses set up are removed from the tube plate and front end plate of the fire-box. Our readers are already familiar with the open-type high-speed vertical engines with shaft governors, and the traction engines with spring gear, made by this firm. It is scarcely necessary to mention that the finish displayed on the various exhibits is of the highest quality. Ransomes, Sims and Jefferies, Limited, Ipswich, are showing a 4 nominal horse-power compound steam tractor specially designed to work under the Light Locomotives Act; a 6 nominal horse-power compound traction engine; 6 nominal horse-power single-cylinder engine of the same type; and a single-cylinder portable of the same power. In the last named the crank shaft revolves in massive bearings mounted on wrought iron brackets, and the boiler is of ample size. Thrashing machines, ploughs, cultivators, and other farm implements complete the display made by this firm.

Ruston, Proctor and Co., Ltd., Lincoln, have a comprehensive display, including a 11¼in. and 17¼in. by 26in. tandem compound drop valve engine fitted with the Recke-Ruston positive valve gear, which has been illustrated in THE ENGINEER, April 9th, 1909; centrifugal pumps of the helical pattern; 40-48 brake horse-power suction gas engine with self-starter and mechanical oiler to the small end of the connecting-rod and trunk; a suction gas plant; fixed oil engines; portable simple and compound steam engines; thrashing machine and clover huller, all of which are provided with their latest improvements, and display the usual high degree of workmanship. Messrs. Ruston road spur wheel. A two-cylinder compound spring-mounted steam tractor under five tons tare, and a single-cylinder general purpose traction engine complete this firm's exhibits.

Clayton and Shuttleworth, Limited, Lincoln, show two single-cylinder traction engines, a single cylinder road roller, a single-cylinder portable engine, and a compound motor tractor amongst other things. The traction engines are of the 6 and 7 N.H.P. sizes respectively, and are specially suitable for hauling and driving thrashing machinery. The firm is also showing two centrifugal pumps of the swivelling type, which allow of both the suction and delivery pipes being adjusted to any angle, an important feature when the pumps have to be used in awkward positions. These pumps are very suitable for drainage and irrigation purposes, being easy of access and possessing few parts to get out of order.

Davey, Paxman and Co., Limited, Colchester, are represented by an 18-20 horse-power gas engine and suction gas producer with rocking grates. The engine has a low-tension magneto system variable while the engine is running, and a step governor which allows a small charge of gas to be taken into the cylinder before cutting out completely. The main bearings of this engine are provided with self-oiling chain lubrication, and a continuous system of oiling the big end. The 7 horse-power traction engine which this firm has on view is fitted with Paxman's patented lubricator worked off the excentric, which also drives the feed pump. The stroke is variable at will by the driver, and the lubricator is so arranged that the cylinder can be flushed with oil when desired. The operation of the lubricator and the amount of oil being used can be observed through a sight-hole. Another feature of Paxman's engines is that the cylinders are bolted down to planed seatings riveted to the boiler barrel, the steam inlet elbow being cast with the cylinder and bolted to the same seat, thus obviating leaky joints.

In addition to the firms already mentioned the following are also exhibiting traction and portable steam engines:—Barrows and Co., Limited, Banbury; Aveling and Porter, Limited, Rochester; William Allchin, Limited, Northampton; Wm. Foster and Co., Limited, Lincoln; W. Tasker and Sons, Limited, Andover; Fodens, Limited, Sandbach; Wallis and Steevens, Basingstoke; and J. and H. McLaren, Leeds.

The firm of Thomas Robinson and Son, Limited, Rochdale, has a comprehensive display of flour milling machinery and wood-working plant. Although the roller mills bear a close resemblance to those for which the firm has been well known in the past, the internal mechanism has undergone steady improvement. The double diagonal "break" roller mill, with rolls 10in. diameter by 60in. long, for instance, has a new micrometer adjustment to the rolls and a first break fluting. The feature of the new first break fluting is that one of the rolls is fluted very coarsely and the other very finely, instead of having both rolls similarly fluted. The differential is also improved. The reasons for these alterations both in the fluting and differential are:—(1) By using a coarse fluted roller for the fast one, the particles of semolina are able to lodge in the grooves instead of being crushed or broken as they were formerly, the result of which is that a much larger percentage of semolina is made, of a better shape and quality; (2) by using a finely fluted roll for the slow one, the grains of wheat are held in position without injuring the outer covering or bran; (3) the increased differential splits open the berry and releases the maximum amount of middlings with a minimum quantity of break flour; (4) both rolls run with teeth backward, which produces a much larger percentage of broad bran; (5) a much greater release is made with this style of fluting, because it is possible to come down more heavily without injuring any of the products. This roller mill is also provided with new bearings, including an improved self-lubricating arrangement, and a double roller-feed is fitted. This section of the firm's exhibit also includes a Dreadnought grinding mill with 30in. stones, and two machines of the cyclo-pneumatic process, in which the separation is effected by specific gravity instead of by size and shape as formerly. The wood working section included a vertical hollow-spindle mortising machine; a four-cutter planing and moulding machine; a two-spindle saw-bench; a roller-feed saw-bench; a universal wood worker; a planing machine; hand saw, &c. Most of these have already been illustrated in THE ENGINEER.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION OF STUDENTS.—By the kind co-operation of several members and their friends, a visit will be made by motor cars on Wednesday, the 30th June, 1909, to Stakeford Bridge and Blyth Harbour Works, on the invitations of Messrs. D. Balfour and Son and Messrs. J. Watt Sandeman and Son respectively. Members are requested to meet in the vestibule of Collingwood Buildings, Newcastle, at 1 p.m.

STATUS PRIZE.—We are asked to remind our readers that Wednesday, June 30th, is the last date for the receipt of papers in the competition for the Status Prize, of which particulars were published in our issue of March 19th last. It will be remembered that this is a prize offered by the Society of Engineers for the best paper on the subject of "How to Improve the Status of Engineers and Engineering, with special reference to Consulting Engineers."

THE UNIVERSITY OF LIVERPOOL.—A copy of the syllabus of the Faculty of Engineering of the University of Liverpool for the session which starts on the 5th October next has been sent to us. The main alterations that have been made are:—The inclusion of naval architecture as a recognised source of study. The course leading to the final examination for the degree of B. Eng. has also been slightly rearranged. For example, the strength of materials and theory of machines are taken from the more professional sections and placed with engineering design and drawing as compulsory subjects. Honours schools for mechanical, civil and electrical engineering and naval architecture have been established in place of the more general course leading to the degree of B. Eng. with Honours. In short, this means that studies for the first three years leading to the final degree of B. Eng. are general in character, while in the fourth or Honours year the men are allowed to specialise to a considerable extent, but not too closely. We are asked to state that the Dean of the Faculty of Engineering will be pleased to see intending students at any time up to July 30th.

YORKSHIRE MINERS' ASSOCIATION.—The annual demonstration of the Yorkshire Miners' Association took place in Sheffield on Monday. It is estimated that between 60,000 and 70,000 miners and their wives walked in procession through the city to Endcliffe Park, where the meetings were held. The statement showing the financial position of the Association was delivered simultaneously from each of the three platforms. This showed the total worth of the society to-day to be £307,000, an increase of £40,000 on the year. There are 79,825 members of the Association, an increase of 999 since December 31st last. At each platform two resolutions were proposed and carried. The first resolution was as follows:—"This annual demonstration of the Yorkshire Miners' Association rejoices to know that, out of 106,742 men and boys employed in our mines, 79,825 are paying members. We also press for an increased standard and minimum rate upon which the percentages shall be calculated, by placing the present percentages on the 1888 rates, and making this the standard and minimum for the future, believing the coal trade in particular, and other trades in general, will not suffer by such an alteration." The second resolution conveyed the best thanks of the meeting "to the Government and all classes and parties in the House of Commons and in the country who have supported measures placed upon the Statute-book in favour of social reforms," and pressing for further reforms in the near future.

ROYAL METEOROLOGICAL SOCIETY.—The last meeting of this Society for the present session was held on Wednesday afternoon, the 16th inst., at 70, Victoria-street, Westminster, Mr. H. Mellish, president, in the chair. A paper by Mr. R. C. Mossman, F.R.S.E., on the "Interdiurnal Variability of Temperature in Antarctic and Sub-Antarctic Regions," was read by the Secretary. The author discussed the day-to-day difference in the mean temperature of successive days at a few places in the antarctic regions for which the necessary detailed daily observations are available. The greatest mean annual temperature variability, viz., 5.9, was recorded during the "drift" of the Belgica in the ice pack, this high value being closely followed by a mean of 5.3 at the South Orkneys. In the Victoria Land region, Rose Island and Cape Adare having a somewhat lower temperature variability of 4.5, the values of the southern station being higher in summer and autumn, and lower in winter and spring than at the northern station. South Georgia occupies an intermediate position between a continental and an oceanic climate in its curve of variability, the mean monthly values varying according to the proximity of the pack ice. At this station the seasonal values show a small variation, and this is also the case at Ushuaia in Tierra del Fuego. The variability at the Falkland Islands and New Year's Island is very small, pointing to the conserving influence exerted by the insular conditions which prevail at these places. The maximum variability occurs in winter, and the minimum in summer, at the three antarctic stations, as well as at South Georgia and the South Orkneys. The smallest variability at any season for any station occurs at the South Orkneys in summer, being only 1.4. It is at this season that cloud amount and fog frequency are at a maximum, while at the same time rapidly moving cyclonic disturbances are of infrequent occurrence. Mr. Ernest Gold described some experiments which he and Dr. W. Schmidt had made with a view to ascertaining if appreciable errors could enter into the temperatures recorded in balloon ascents owing to errors in the alcohol-carbonic acid method of testing the apparatus. Mr. L. C. W. Bonacina read a brief paper advocating the use of freely-exposed thermometers in addition to sheltered ones.

HIGH-PRESSURE FIRE SERVICE PUMPING STATION AT WINNIPEG

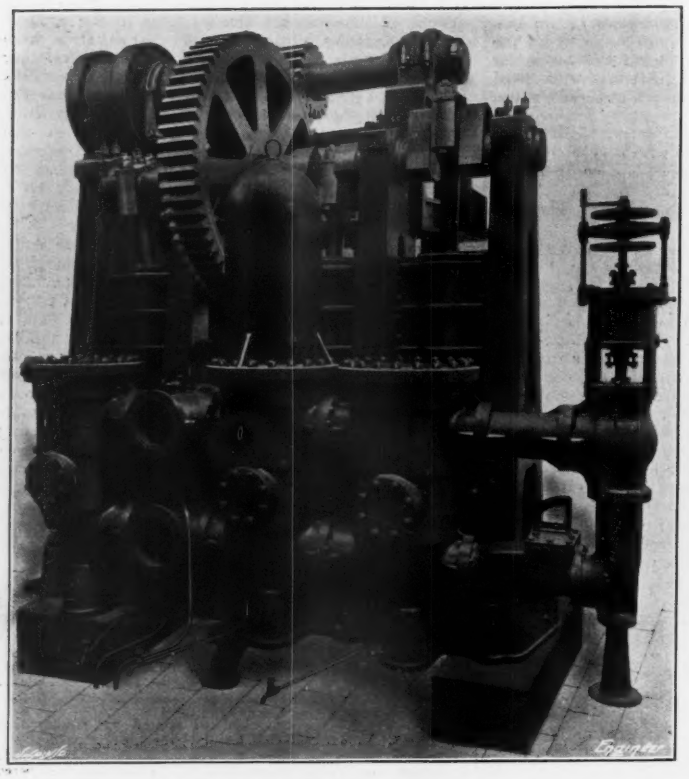


Fig. 1—THE LARGER PUMPS

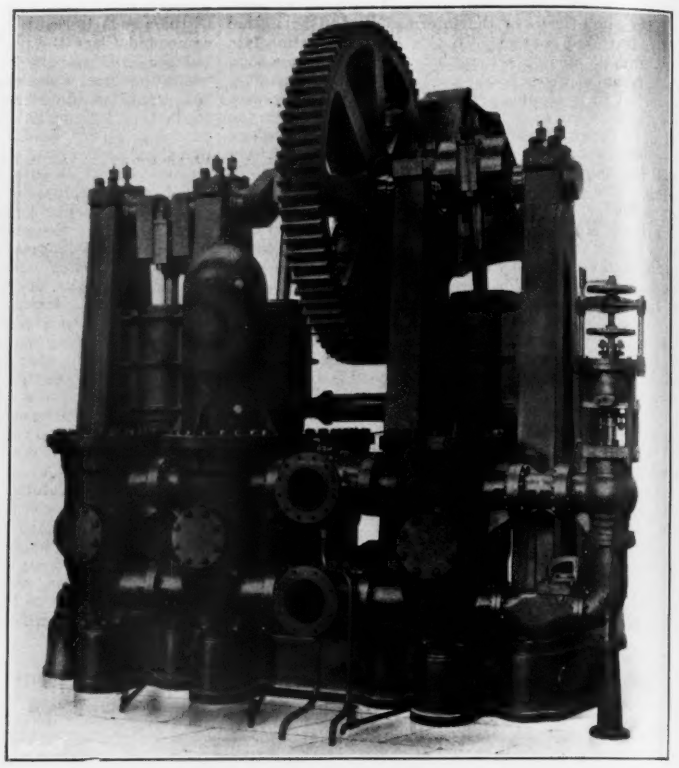


Fig. 2—THE SMALLER PUMPS

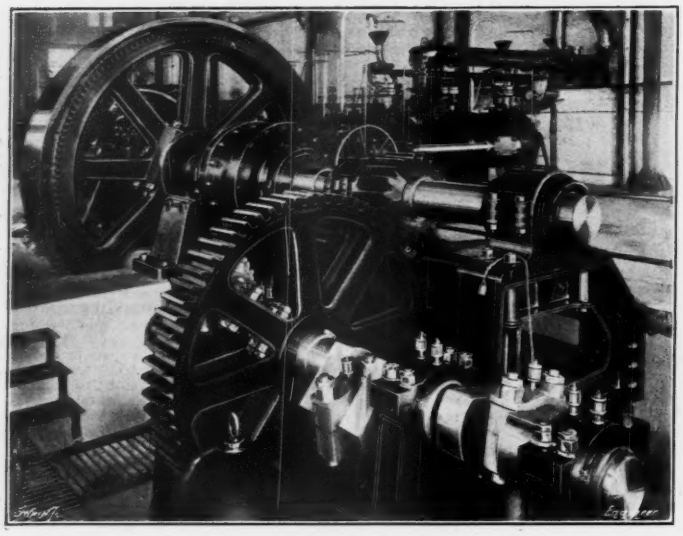


Fig. 3—PUMP GEARING

Fig. 4—PRODUCER HOUSE SHOWING CONVEYORS

WINNIPEG HIGH-PRESSURE FIRE SERVICE.

IN September, 1905, it was decided to install at Winnipeg a high-pressure gas-driven fire service water supply on similar lines to that laid down at Philadelphia in 1903. In the latter case Westinghouse gas engines are used driving three-throw "Deane" pumps; but Colonel H. N. Ruttan, the Winnipeg city engineer, drew up a specification to which a very large number of firms quoted, with the result that the tender of W. Jacks and Company, of Glasgow, was accepted, including gas engines and producer plant made by Crossley Brothers, Limited, of Manchester, and pumps made by Glenfield and Kennedy, Limited, of Kilmarnock. The original estimated cost of the plant was 560,000 dollars; but in August, 1907, it was thought desirable to make alterations and extensions, so that the ultimate cost of the plant, mains, &c., was nearly 1,000,000 dollars. Owing to the rapid growth of the city, whose manufacturing output had increased 120 per cent. in the past five years, and to the large and costly buildings which had been erected, it was an absolute necessity that an efficient means of dealing with outbreaks of fire should be provided; and after much careful investigation the system since adopted was decided on.

The power-house, 158ft. long by 92ft. wide, is situated near the Red River, whence the water is drawn. It is divided into two bays, each spanned by a 20-ton crane travelling the full length of the building, and operated from the floor of the engine-house. They are supported on strong wrought iron standards, which also help to carry the roof. The water mains vary in diameter from 8in. to 20in., and are over eight miles long. There are in the circuit eighty-six fire hydrants, and the water is maintained in the mains at 300 lb. pressure per square inch. The hydrants are connected to the mains by 8in. diameter pipes. They are provided with 4in. to 4½in. hose-nozzles with independent valves, so that each may be cut out from the system in case of necessity. These nozzles are, when required, reduced to 3½in. and 2½in. by suitable reducers—3½in. being the largest hose now used. The engine-house floor is 18ft. below the street level; and the pumps are fixed in a trench on foundations 12ft. below those of the engines. The two main suction pipes are 24in. in diameter at the large end, and draw water from two suction wells 9ft. square, 40ft. deep, measured from the street level, divided by a concrete wall. The water is led to the well by an intake pipe 3ft. in diameter, which extends for a distance of 425ft. from the well to the deep water in the river, where it ends in a stone-ballasted crib. There are two delivery mains in the engine house, each 20in. diameter, to which all the pumps are connected; and should a burst occur either can be cut off and the water can be pumped into the other. The engines are usually run with gas made in a 3000 horse-power Crossley producer plant; but to guard against the remote possibility of the plant being out of order at any time when required, the engines are made suitable for working with coal-gas; and a supply from the city gas mains is laid to the gas-holder.

The plant consists of four of Crossley's double-cylinder single-acting engines of 500 brake horse-power each, and two smaller units of similar design, of 250 brake horse-power each. Each engine has two single-acting cylinders, placed tandem fashion, as shown in Figs. 5 and 7, the diameter being 32in. and the stroke 36in. in the larger, and 25in. by 30in. in the smaller. The larger engines run at 125 revolutions per minute, and the smaller at 150 revolutions per minute. The exhaust valves are of the balanced type, working horizontally, and are readily accessible, as they can be drawn out at the floor level for examination and cleaning. The special feature of the admission valves is already familiar to our readers, and consists in the arrangement for adjusting the gas supply in accordance with the requirements of the engine as the load varies. There are, in short, in each case two valves—a main valve and a gas valve. The former is positively driven in the ordinary manner, and is of the usual mushroom pattern. The gas valve is mounted, with a sliding fit, on the spindle of this main valve. The two valves—the main and the gas valve—always close together; but whilst the main valve is positively opened, the gas valve is opened by a special spring arrangement. The time at which it opens—and consequently the quantity of gas drawn into the cylinder—is under the control of the governor. With this object the gas valve is coupled to a piston working in a vacuum cylinder. This cylinder communicates with the open air by a small piston valve, the position of which is controlled by the governor. At full load the piston valve is held wide open, and air can readily enter the vacuum cylinder, and the gas valve is, accordingly, free to move as soon as the slightest vacuum is established below it. As a consequence, the engine receives a full charge. As the load on the engine falls off, the governor partially closes the small piston valve above mentioned, and the gas valve cannot then open so freely, its motion being checked by the fact that as soon as it begins to move there is a reduction of pressure in the vacuum cylinder behind it. It therefore opens later, and less gas enters the working cylinder. This method of regulation has been found to be very sensitive and reliable in operation.

The engines, as stated, are single-acting. The open-ended cylinders enable the condition of the piston and of the lubrication to be seen whilst the engine is running. The pistons can be drawn forward, without removal from the rod, far enough for a man to get inside the cylinder for inspection and cleaning when necessary. Moreover, there is only one piston-rod gland and one set of guides. The valves are driven by bevel and spur gearing from the main shaft, as shown in our illustration—Fig. 5. Each cylinder is fitted with two independent low-tension magneto ignitions, either of which can be overhauled without interfering with the other. All the engines are fitted with water-cooled pistons and piston-rods, and the glands are packed with metallic rings.

The engines are started by means of compressed air at a

pressure of 175 lb. per square inch. The air compressors are in duplicate, and are of the vertical two-stage type, 6½in. and 7½in. diameter by 10in. stroke, and run at 150 revolutions per minute. Each is capable of charging a receiver of 32 cubic feet capacity in 13½ minutes to 175 lb. per square inch. Two receivers, 2ft. 9in. diameter by 6ft. high, are provided; and the whole six engines can be started and be working under full load in 3½ minutes from receipt of a fire call. The circulating water for cooling the engine cylinders is provided by a set of three-throw vertical single-acting ram pumps 9in. diameter by 10in. stroke, delivering 18,750 gallons per hour. The pumps are driven by cast iron double helical gearing, of mild steel in one forging, having three throws for 18in. stroke. The valve boxes are fitted with deck plates into which are fitted a large number of small valves of the vulcanite disc-and-spring type. The suction and delivery mains are arranged in two lines in a trench formed in the concrete running through the centre of the house, one right and the other left-hand.

The suction mains are each 24in. diameter at one end, tapering to 16in. diameter at the other. The delivery mains are each 20in. diameter at one end and tapering to 14in. at the other, each delivery main being fitted with an air vessel 30in. diameter by 18ft. high at the outlet end, with a sluice

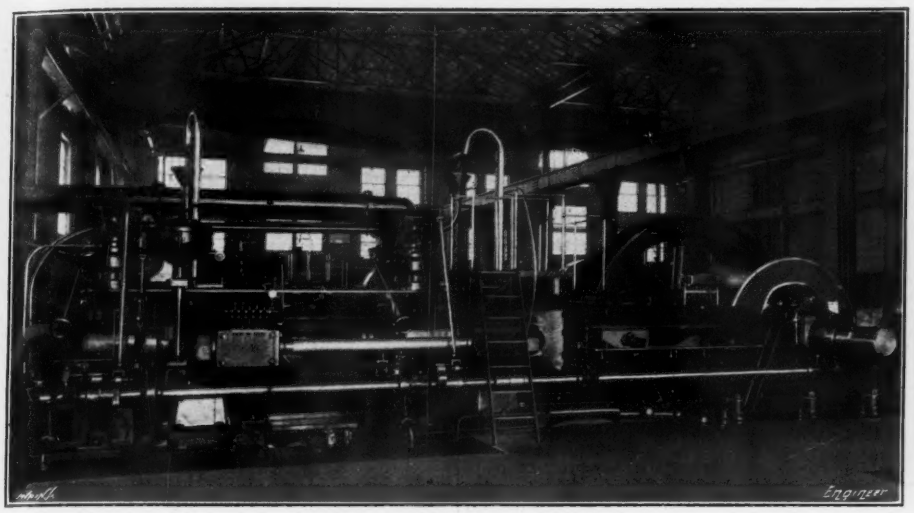


Fig. 5—INTERIOR OF POWER STATION

and are fitted with fast and loose pulleys. The pumps, like the air compressors, are driven by means of belts from an overhead shaft driven by a 30 brake horse-power gas engine. This engine is also duplicated, so that every possible precaution has been taken against breakdown. If necessary, water from the town's supply or from the pressure mains can be utilised, a gravity service from a tank 17ft. by 10ft. by 5ft., placed in the roof, being provided.

The four larger engines are fitted with Hele-Shaw friction clutches, which transmit the power to the pump shafts, and enable them to be thrown out of gear at starting. The six sets of pumps are of the vertical double-acting piston type. Four of them have pistons 13¾in. diameter by 18in. stroke, and are each capable of delivering 1800 gallons per minute against a pressure of 300 lb. per sq. in. when running at a speed of 35 revolutions per minute—Fig. 1. The remaining two sets have pistons 9¾in. diameter by 18in. stroke, and are each

Fig. 6—TESTING WATER JETS

capable of delivering 900 gallons per minute running at the same speed—Fig. 2. The gearing—Fig. 3—is fixed on an extension of the crank shaft, which is supported on cast iron brackets resting on concrete foundations, and also bolted to the side of the A frames of the pumps. Each set of pumps is fitted with a by-pass controlled by a hydraulically operated valve. When starting up the pumps this valve on the by-pass is left open so that there is no back pressure on the piston, and as soon as the engine comes up to speed the by-pass valve can be gradually closed. The by-pass is also fitted with a waste water meter, so that by simply opening the by-pass and closing the valve on the discharge pipe, the delivery of the pumps can be ascertained approximately at any time. The pump pistons are of gun-metal, fitted with leather cups, diaphragm and junk ring. The piston-rods are of forged bronze, and are secured to the pistons by means of nuts, and to the crossheads by a strong cotter. The crank shafts are valve beyond this on the outside. There is in addition to the larger air vessel a small one on each set of pumps. Suitable cocks are provided for charging the air vessels by means of the air compressor used for starting the gas engines. Each set of pumps is connected to both these lines of suction and delivery mains by 12in. and 9in. pipes respectively, for the large and small pumps and provided with suitable valves to allow of pumping into either or both mains at will.

The gas-producing plant—Figs. 4 and 8—is in a building attached to the engine-house. The producers are in four units, so as to allow of economical running when only one of the pumping engines is in use, two being of 6ft. 6in. and two 8ft. 6in. diameter by 18ft. high, each being fitted with a rotating fire-grate and water-luted ash-pits. A continuous platform connecting the producers supports overhead coal hoppers, which are supplied with fuel from a large receiving hopper at one end of the building by means of a bucket elevator and worm conveyor. Each producer is connected to a tubular superheater and hot-gas boiler, so arranged that the heat of the hot gas, otherwise wasted, is used to superheat the air and steam supplied to the producers, and also to generate a large proportion of the steam required. The superheaters and boilers are so constructed that the tubes can be scraped when in operation, the dust and tar being removed from the water lutes below. The hot gas passes from the boilers to an overhead hydraulic main, which is provided with seal pots and bells to isolate any of the producers. Collecting boxes with lutes are fitted to it, so that tar, &c., can be removed without stopping the plant. This main is connected to four vertical coolers, each 5ft. diameter and 30ft. high, partially filled with coke, and provided with a water spray at the top. The gas passes through the saturated coke, which removes the heavy tar and dirt, and reduces it to atmospheric temperature, then to three rotary tar extractors, each provided with isolating valves and separate water supplies. The extractors remove the lighter tar and oils, which it is impossible to do with the scrubbing and cooling arrangements usually employed. After leaving the tar extractors, the gas passes through two sawdust scrubbers, each 9ft. diameter and 22ft. high, to a gasholder of 250,000 cubic feet capacity, adapted for either producer or city gas, and sufficient to operate the whole plant for 1½ hours with producer, and five hours with city gas. Thus ample time is given to start additional producers, or to make provision for the use of city gas in case of a prolonged fire. The hot water, after passing through the coolers, is collected and cooled in a sump, from which the tar is removed daily, the water being again returned through the coolers by 4in. centrifugal pumps. The pumps and tar extractors are driven by a 20 horse-power gas engine through overhead shafting, and are in duplicate. Air is supplied by three

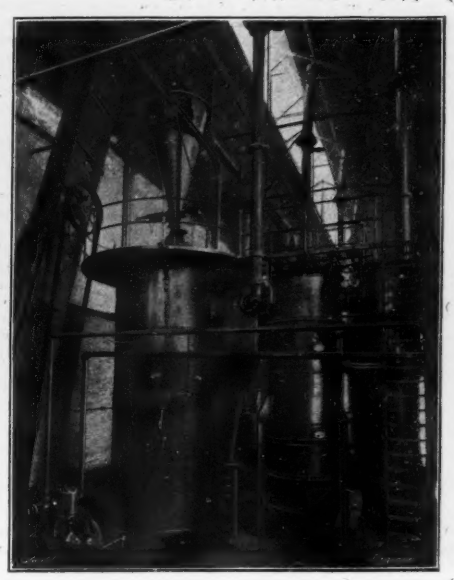


Fig. 8—PRODUCER HOUSE

steam-driven "Roots" blowers, each having an output of 100,000 cubic feet per hour, one being a standby. The coal elevator and conveyor are driven by a steam engine, the exhaust steam from this engine and the blowers passing to the producers with the air blast. Steam is supplied by two tubular boilers 7ft. diameter and 8ft. 6in. long, of the dry-back marine type, fired by gas. The gasholder has guide standards and two lifts, the bottom tank, which is 81ft. diameter, being surrounded by a wall. Steam heating coils are fixed between the wall and the tank, with steam jets connected to the seal cup of the top lift by swivel pipes, to guard against the severe frosts in winter.

The plant can work with either bituminous, anthracite, lignite coals or coke, and is guaranteed to deliver 75 per cent. of the calorific value of the fuel. It was worked

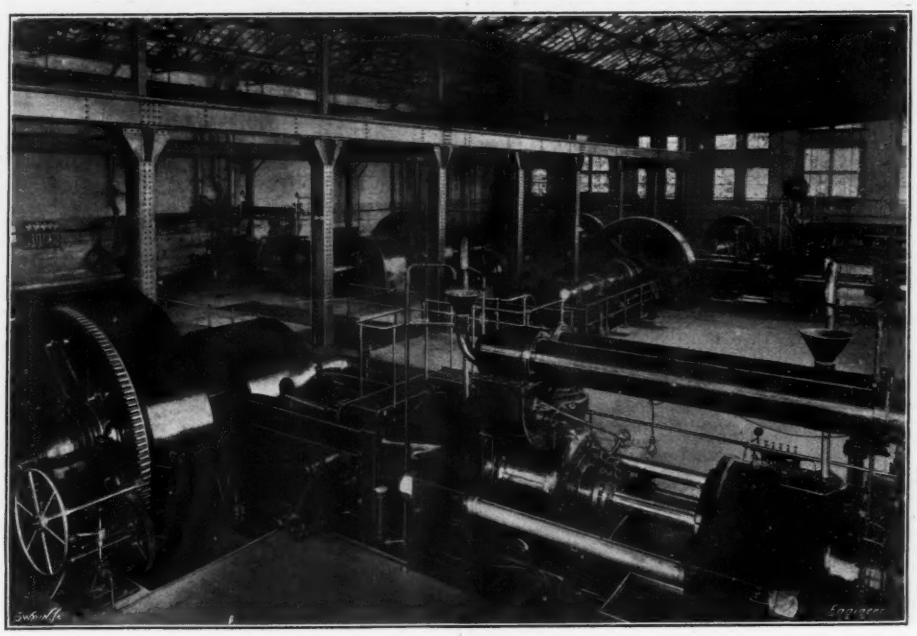


Fig. 7—GENERAL VIEW OF POWER STATION

under inspection for three months day and night, the load varying from 120 to 3000 horse-power. Each unit was tested separately with a week's continuous run, and all the fuels specified were used. Finally, a 50 per cent. overload test was made using lignite coal—that is, the whole of the pumping plant was operated with one large and one small producer, two blowers, two extractors, one centrifugal pump, and one gas engine. At the official test of five hours' continuous running of the six engines at full load, before finally taking the plant over, the following excellent results were obtained :—

	250 h.p. sets.	500 h.p. sets.
B.T.U. consumed per indicated h.p.	7,741	8,664
B.T.U. consumed per water h.p.	9,404	11,174
Cubic feet of gas consumed per ind. h.p. hour	77.5	72.9
" " " water "	94.1	94.2
Duty in foot-pounds of work done per 1,000,000 B.T.U. consumed	211,566,500	177,246,250
Thermal efficiency ratio per ind. h.p.	.481	.284
" " water "	.2 1	.277
Mechanical efficiency of pumping unit	82.1	77.5

As a result of the existing comparative immunity from destruction through fire, the various insurance companies have lowered their rates.

This is claimed to be the largest gas-driven pumping station in the world, and the city engineer is to be congratulated upon its success. The results of the tests are remarkable, the general efficiency being higher than was anticipated. When the Philadelphia plant was tested in May, 1904, the number of B.Th.U. per brake horse-power hour was found to be 11,160, a result which has been far surpassed in the present case. At Coney Island, near New York, there is a similar high-pressure fire-station, but on a smaller scale than either of the two mentioned above. It consists of three "Nash" inverted vertical gas-engines of 150 horse-power each, made by the Goulds Manufacturing Company, each driving a set of three-throw double-acting pumps 12in. diameter by 14in. stroke, delivering 1500 gallons of water per minute against a pressure of 150 lb. per square inch. The combined output of the plant is 4500 gallons per minute. At the official trial before the plant was taken over it was found that the average B.T.U. per pump horse-power was 12,682.

Owing to the much greater height of buildings in America and Canada as compared with those in this country, the high-pressure fire service is almost a necessity. It is no uncommon thing to find buildings which approach or exceed 300ft. in height. This imposes a head of approximately 150 lb. per square inch, apart from that necessary to overcome the friction of hose and nozzles. The size and weight of portable fire-engines to deal with this pressure is almost prohibitive, and it has been proved that the best means is an independent high-pressure pipe system, fed from a centrally situated pumping station with hydrants for attachment to hose pipes. The cast iron mains are constantly charged at the full pressure, and loss of time in reaching a fire with a portable engine is avoided.

THE PRODUCTION OF CEMENT IN CANADA, 1908.

THE Mines Branch of the Canadian Department of Mines has received from the producers complete statistics of the production of Portland cement in the Dominion in 1908, and has recently published them. According to these returns, the total quantity of Portland cement made in Canada in 1908 was 3,495,961 barrels of 350 lb. net, as compared with 2,491,513 barrels in 1907, or an increase of 1,004,448 barrels or 40.3 per cent. The total quantity of Canadian Portland cement sold in 1908 was 2,665,289 barrels, as compared with 2,436,093 barrels in 1907, or an increase of 229,196 barrels or 9.4 per cent. The total consumption of Portland cement in 1908, including Canadian and imported cements, was 3,134,338 barrels of 350 lb. net, as compared with 3,108,723 barrels in 1907, or an increase of 25,615 barrels or 0.8 per cent. In addition to the above, other important statistical returns respecting the stocks on hand at the beginning and end of the year, the total value and average price per barrel, the number of men employed and wages paid, the quantity and value of the imports, &c., for the years 1907 and 1908, are shown in comparative form in the following table:—

Comparisons of Production, Sales, and Imports of Portland Cement in 1907 and 1908.

	1907.	1908.	Increase or decrease.
Cement sold, barrels	2,436,093	2,665,289	+ 229,196
Cement manufactured, barrels	2,491,513	3,495,961	+ 1,004,448
Stock on hand, Jan. 1st, barrels	299,015	383 349	+ 84,334
Stock on hand, Dec. 31st, barrels	354,435	1,214,021	+ 859,586
Value of cement sold, dols.	3,777,328	3,709,139	- 68,189
Average price per barrel, dols.	1.55	1.39	- 0.16
Wages paid, dols.	956,080	1,275,638	+ 319,558
Men employed, number	1,786	3,029	+ 1,243
Imports of Portland cement, barrels	672,630	469,049	- 203,581
Value of cement, dols.	837,520	531,045	- 306,475
Average price per barrel, dols.	1.24	1.13	- 0.11
Total consumption of cement in Canada, barrels	3,108,723	3,134,338	+ 25,615
Number of completed plants operated	17	23	+ 6
Total daily capacity of operating plants as at Dec. 31st, barrels	14,400	27,500	+ 13,100

The production of Portland cement in 1908 was derived from twenty-three operating plants, with a total daily capacity of 27,500 barrels, equivalent to about 8,250,000 barrels per year of 300 days, or 10,000,000 if all plants were run continuously for the whole year. The operating plants were distributed as follows:—One in Nova Scotia using blast furnace slag; 1 in Manitoba making a natural Portland cement; 1 in British Columbia, 2 in Alberta, and 3 in Quebec using limestone and clay; and 15 in Ontario, of which 12 use marl and 3 limestone. The total daily capacity of the plants using marl was 10,400 barrels, as compared with 17,100 barrels per day for all other plants. Of the total quantity of cement made in 1908, 1,573,090 barrels were made from marl, and 1,922,871 barrels from limestone and slag. It is not possible, adds the report from which we take the foregoing, to give the detailed production in all of the Provinces without divulging confidential returns. The following groupings, however, may be made:—(1) Quebec and Nova Scotia; (2) Ontario; (3) Alberta, Manitoba, and British Columbia. The production in these groups in 1907 and 1908 was as follows:—

(1) *Quebec and Nova Scotia.*

	1907.	1908.	Increase.
Cement sold, barrels	456,579	749,021	+ 292,442
Cement manufactured, barrels	456,625	953,712	+ 497,087
Stock on hand, Jan. 1st, barrels	40,200	40,246	+ 46
Stock on hand, Dec. 31st, barrels	40,246	244,937	+ 204,691
Value of cement sold, dols.	664,866	1,051,144	+ 386,278
Wages paid, dols.	104,116	293,855	+ 189,739
Men employed, number	305	795	+ 460
Total daily capacity of operating plants, barrels	2,300	7,900	+ 5,600

(2) *Ontario.*

	1907.	1908.	Increase or decrease.
Cement sold, barrels	1,775,484	1,518,886	- 256,598
Cement manufactured, barrels	1,816,662	2,016,737	+ 200,075
Stock on hand, Jan. 1st, barrels	242,248	314,579	+ 72,331
Stock on hand, Dec. 31st, barrels	283,425	812,430	+ 529,004
Value of cement sold, dols.	2,705,167	1,909,815	- 795,352
Wages paid, dols.	684,964	636,955	- 48,009
Men employed, number	1,192	1,619	+ 427
Total daily capacity of operating plants, barrels	9,400	14,900	+ 5,500

(3) *Manitoba, Alberta, and British Columbia.*

	1907.	1908.	Increase.
Cement sold, barrels	204,030	397,382	+ 193,352
Cement manufactured, barrels	218,226	525,512	+ 307,286
Stock on hand, Jan. 1st, barrels	16,567	28,524	+ 11,957
Stock on hand, Dec. 31st, barrels	30,763	156 654	+ 125,891
Value of cement sold, dols.	407,295	748,180	+ 340,885
Wages paid, dols.	167,000	344,828	+ 177,828
Men employed, number	289	615	+ 326
Total daily capacity of operating plants, barrels	2,700	4,700	+ 2,000

As already stated, the average price at the works during 1908 as returned by the manufacturers was 1 39 dols. per barrel. Prices in car lots, ex-package, at Toronto and Montreal, according to trade quotations, ranged from 1.90 dols. in January to as low as 1.55 dols. in December. In Winnipeg prices ruled during the latter half of the year at about 2.40 dols. There is very little cement exported from Canada, only 34,591 dols. worth being recorded for 1908. The imports of Portland cement, which were, previous to 1904, larger than the Canadian production, have been decreasing since 1906, and were in 1908 equivalent to but 17.6 per cent. of the sales of Canadian cement, or 14.9 per cent. of the total consumption. A duty of 12½ cents per 100 lb., equivalent to 43¾ cents per barrel of 350 lb. net, is levied on imports. The weight of the package is, however, included for purposes of duty. The imports of cement during 1907 and 1908 by countries were as follows:—Great Britain, 1907, 1,003,444 cwt.; 1908, 601,527 cwt. United States, 1907, 1,134,113 cwt.; 1908, 902,576 cwt. Belgium, 1907, 182,943 cwt.; 1908, 128,738 cwt. Other countries, 1907, 33,704 cwt.; 1908, 8831 cwt.

In the following tables statistics of the production and consumption of cement in Canada are given for the past five years:—

(1) *Annual Production of Portland Cement*, 1904–1908.

Calendar year.	Cement made.	Cement sold.	Average price per barrel.
	Barrels.	Barrels.	Dols.
1904	908,990	910,358	1.41
1905	1,541,568	1,346,548	1.42
1906	2,152,562	2,119,764	1.49
1907	2,491,513	2,436,093	1.55
1908	3,495,961	2,t65,289	1.39

(2) *Consumption of Portland Cement in Canada*, 1904–1908.

Calendar year.	Canadian.	Imported.	Total.
	Barrels.	Barrels.	Barrels.
1904	910,358	784,630	1,694,988
1905	1,346,548	917,558	2,264,106
1906	2,119,764	665,931	2,785,69C
1907	2,436,093	672,630	3,108,723
1908	2,655,289	469,049	3,134,338

From the foregoing it will be seen that whereas the importation of cement into Canada has decreased very considerably, the manufacture and use of Canadian cement has of recent years been steadily increasing.

THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

THE above Association has been holding its fourteenth Annual Convention in Manchester during the past week, which was fittingly opened at the Manchester Town Hall on Monday evening, when the Lord Mayor (Mr. Alderman Holt) and the Mayoress (Mrs. Holt) received the delegates and other visitors, about 1000 in number. On Tuesday the business of the Convention commenced at the Technological School, under the presidency of Mr. S. L. Pearce, Chief Electrical Engineer of Manchester, when upwards of 250 delegates attended. Of course, the unexpected always happens, and a temporary defect in the electric lighting of the room led the Lord Mayor, amid much laughter, to remark that there were many factors in connection with electricity which required development. In the course of his address, the President (Mr. S. L. Pearce) said that the growth of their Association had been coincident with the development of municipal undertakings. In 1897 the total capital sunk in electrical supply works, including traction by local authorities, was £3,509,000. To-day this figure was £83,860,000. The success which had attended their branch of municipal enterprise, judged not merely from the point of view of sales and cost of production, but also from a sounder financial position of the majority of undertakings, had done much to silence the criticism of those who would contend that municipal undertakings were neither progressive nor businesslike. The name of Manchester was always associated with that of its first consulting electrical engineer, the late Dr. John Hopkinson, to whose genius the electrical world generally owed so much. As a striking commentary on the advance of electrical science, he mentioned that practically none of the electrical plant installed by Dr. Hopkinson, in the early days of the undertaking, from 1893 to 1897, now remained, all of which enforced the necessity of financial provision being made at the commencement of an Electricity Supply Undertaking Committee, so that it might be in a position to replace and write down its plant as the exigencies of time dictated. On the old question of financial stability, Mr. Pearce said it was at least arguable whether the object of all municipal undertakings should not be to supply current at, or near, cost price, and not relieve the rates out of profits to benefit non-consumers. The former course would ultimately be of benefit to the municipality in inducing the founding of new businesses, with the consequent addition to the ratable value of the city. Unfortunately, the tendency at the present time, in view of ever-increasing rates, was to look to the trading departments for more and yet more relief, in the shape of increased contributions. So far as lay in their power this tendency should be resisted, as being detrimental to the best interests of trading concerns. The recent decision of the House of Lords Committee, on the gas clauses in the Salford Corporation Bill, was noteworthy by reason of its bearing on this question of rate aid from trading departments. The corporation were in future to be allowed to use in relief of rates 1 per cent. upon their capital, equivalent to some £6000 per annum, instead of about £28,000, the amount previously contributed. In a review of matters that had come under their notice during the past year he said that the advent of the metal filament lamp emphasises one thing, and that was the utmost importance of having the people educated up to the advantages offered by the high efficiency lamps. "Particularly does this apply to those householders on the line of route of existing distributing mains, so that by a trifling capital expenditure a substantial addition to the revenues may be obtained." On the craze for cheap wiring he remarked that on one point all were agreed, that cheapened methods of wiring must not involve, in any shape or form, a lowering of the standard of safety. In his opinion a system involving the use of "flexibles" above a given height from the ground, unless those where wires passed through walls, floors, or ceilings, was not inconsistent with the above axiom. After a cordial vote of thanks to Mr. Pearce for his valuable address, Councillor Alex. Sinclair, of Swansea, in a paper for discussion, sought to establish a case for "cheap units." He urged that good business was often lost by trying to obtain too high prices. Alderman T. Higham, of Accrington, speaking as a cotton manufacturer, said they were in a fool's paradise entirely if they thought they were going to get the manufacturers of Lancashire to adopt electrical energy at anything like the prices they had been asking hitherto. In Accrington they were quoting .69d. per unit to the large power users, and had been doing so for four years. This was no use to the cotton trade. It was £ s. d. with the Lancashire cotton manufacturer. He had two or three mills producing power at the low rate of not more than .34d. per unit, including warming the mills. Unless they could give the Lancashire manufacturer something as good as that, they would not get him to change. Municipal prices were too high. After luncheon, the delegates visited the Stuart-street generating station and the Dickinson-street and Bloom-street generating stations. The horse-power of the plant at these three stations amounts to 74,800. The total length of all classes of mains is 345 miles, or 765 miles of single conductor. The present area of supply is 30 miles.

The meeting on Wednesday was held at St. George's Hall, Liverpool. A paper on "The Influence of Metallic Filament Lamps on the Electrical Industry and on Street Lighting," was read by Mr. E. E. Hoadley, and on "Modern Cable Systems," by Mr. E. M. Hollingworth. The remainder of the day was spent in visiting the Lister Drive Generating Station, and the R.M.S. Mauretania. On Thursday the meetings were resumed at Manchester. Papers were read on "Steam Turbines from the User's Point of View," by Mr. A. S. Blackman, and "Notes on Condensing and Water-cooling Plants," by Mr. E. Lunn. After a visit to the British Westinghouse Company's Works, Trafford Park, the annual dinner of the Association was held at the Midland Hotel, Manchester. Friday's meeting, was occupied with the proceedings of the annual general meeting, and in the afternoon a visit was paid to the Salford Electricity Works Pendleton.

THE COUNCIL of the Tramways and Light Railways Association have made arrangements, with the co-operation of some of their members, who are owners of tramways undertakings, to make a series of trials of any speed indicators of merit that may be brought to their notice as a useful addition to the ordinary equipment of a tramway car.

VICKERS, SONS AND MAXIM, LIMITED: COLONEL VICKERS'S RESIGNATION.—Colonel T. E. Vickers, C.B., V.D., in view of his advanced age, has resigned the chairmanship and managing directorship of Vickers, Sons and Maxim, Limited. At their board meeting on Monday, the directors accepted his resignation with regret, and passed a resolution of thanks to him for his services of sixty years to the company. Mr. Albert Vickers was elected chairman of the company. Lieutenant A. Trevor Dawson, R.N., was appointed a managing director, subject to confirmation at the next ordinary general meeting of the shareholders.

ROYAL SOCIETY OF ARTS.—The Council have awarded the Society's silver medal to the following readers of papers during the session 1908-9:—Mr. G. Albert Smith, "Kinematography in Natural Colours;" Mr. Henry C. Brewer, "Gothic Art in Spain;" Monsieur Yves Guyot, "The Commercial Relations of France and Great Britain;" Mr. George Hubbard, "Dew-ponds;" Mr. Walter Rosenhain, "The Application of the Microscope to the Study of Metals;" Mr. Gabriel Gordon Cleather, "The Musical Aspect of Drums;" Mr. C. Reginald Enock, "The Resources of the Peruvian Andes and the Amazon;" Mr. Percy A. Wells, "English Furniture Design and Construction;" Mr. Arthur John Barry, "Railway Development in China;" Herr Sam Eyde. "The Manufacture of Nitrates from the Atmosphere by the Electric Arc;" Mr. Douglas Dewar, "The Birds of India;" Mr. Arthur Anthony Macdonell (Boden Professor of Sanskrit, Oxford), "The Buddhist and Hindu Architecture of India;" Mr. Selwyn Howe Fremantle, "The Problem of Indian Labour Supply;" Mr. Krishna Govinda Gupta (member of the Council of India), "Some Phases of Hinduism;" Mr. Cecil L. Burns (Principal, Bombay School of Art), "The Functions of Schools of Art in India;" the Hon. Charles Gideon Murray, "The Road to South African Union."

THE EXTENSION of the Sudan Government Railway's line south of Khartoum, which forms another stage in the Cape to Cairo Railway, is now being rapidly pushed on, the rate of progress being ten miles a week. The line follows the course of the Blue Nile at a distance of one to three miles west of the river, and does not actually strike the Nile after leaving Khartoum until the thirty-eighth mile. The forty-seventh mile has now just been reached, and the work has proved remarkably easy. The money at present allotted for its construction on this year's estimates will be sufficient to take the line to the sixty-fifth mile. The importance of the line for the development of the country is such that it is probable that some arrangement will be made for continuing the work forthwith. The line is just reaching that part of the country where the rising of May, 1908, took place. Its course eventually will be to cross the desert from the Blue Nile to the White Nile, where a bridge is already under construction at Kosti to carry it up to El Obeid, in Kordofan. There it will tap the centre of the gum trade, one of the chief sources of wealth to the Anglo-Egyptian Sudan. Omdurman will no doubt lose greatly in wealth and importance, and some even predict that it will dwindle away to an insignificant village, so great is the proportion of its wealth depending on the gum trade. It will, however, take long to lose its place as a great centre for caravans, for the pilgrim route to Mecca for an immense distance leads through it.

RAILWAY MATTERS.

THE North-Eastern Railway directors have, it is stated, decided to electrify the branch lines from Newcastle to South Shields, and also from Newcastle to Sunderland.

THE Light Railway Commissioners have submitted to the Board of Trade for confirmation the Crewkerne, South Petherton and Martock Light Railway Order, 1909, authorising the construction of a light railway in the county of Somerset from Crewkerne to South Petherton and Martock.

THE Mexican Central plant at Aguascalientes for preserving railroad sleepers with oil, which was started some years ago as an experimental plant to develop and perfect the Ebano oil process, is now treating about a carload, of 3500 sleepers, daily. Each sleeper takes up about three gallons of oil.

STARTING on July 1st, the London and North-Western Railway will run an express train from Euston to the Welsh coast without a stop. The train will leave Euston at 11.15 a.m., and will not call anywhere until it reaches Rhyl, 209 miles distant, in 237 minutes, the average speed being 53 miles per hour.

THE *Diario Official* (Rio de Janeiro) of 20th May publishes a decree approving the plans and estimate of 10,612,479 milreis (about £663,280) submitted by the Leopoldina Railway Company, Limited, for the construction of a line to join Alegre on the Caravellas Railway, in the State of Santo Spirito, to Manhuassú, in the State of Minas Geraes.

THE Montevideo correspondent of the *Times* cables that an American syndicate is proposing to construct a railway crossing Uruguay from Santa Rosa in the north-west to Puerto Coronilla in the south-east, at a cost of £3,000,000. It will mark a new departure in the history of Uruguayan railways from a financial point of view, for the syndicate will offer to construct the line without asking the State for any guaranteed interest.

ON July 1st the management of the line jointly constructed over twenty years ago by the Great Northern and Great Eastern Companies to connect Lincoln with Sleaford, Spalding, and March, and thence by the Great Eastern line to Liverpool-street, will be vested in the Great Northern Company solely, so far as the line from Lincoln to March is concerned, the Great Eastern controlling the line south of March. Hitherto the line has been managed by a joint committee of the two companies.

IT is reported that the South-Western Railway Company contemplates acquiring a further stretch of foreshore on the Woolston side of the river Itchen, opposite Southampton, for additional dock facilities. The details of the scheme have not been disclosed, but it is stated that a portion of the land will be utilised for building purposes. Meanwhile rapid progress is being made with the construction of the immense deep-water dock at Southampton, and a start will soon be made with the new graving dock at Woolston.

IT is reported that the American Ambassador in London has made on behalf of his Government formal representations to the British Government with regard to the rights of American capitalists to participate in the construction of the Sze-chuan railway. It has been pointed out that American capitalists evinced no desire to participate when negotiations were in progress in 1905, and it is hoped that, this being so, the American claim will not be pressed as regards this particular line. In the future the participation of American capitalists will be welcomed.

THE following information is from the report by H.M. Consul at Corunna on the trade of that district in 1908:—Railways projected are: Orense to Zamora, Corunna to Gijon, Corunna to Corcubion, and Corunna to Santiago. The last-named line has been surveyed, and it is hoped that foreign capitalists will undertake its construction and working. The distance from Santiago to Betanzos—a place 15 miles from Corunna on the Corunna-Leon Railway—is 48 miles, and it is proposed to erect nine stations within this distance. Two strong bridges and at least one tunnel will have to be built.

THERE has been a feeling in India latterly, states the *Railway News*, that the placing in Great Britain of orders for rolling stock for the State Railways should be somewhat curtailed in view of the fact that numbers of native firms have come into existence with the object of specialising in this class of work. Hitherto home firms have had a monopoly in this sphere of industrial activity, but a distinct indication of the awakening of the State Railway authorities to the fact that stock of first-class workmanship can be manufactured in the country is given in the placing of orders recently with a native firm for twelve high-sided and eight low-sided wagons by the North-Western State Railway. It is conceded that the order is a small one, but it is regarded as commencing a new era in Indian engineering circles. Orders have also been recently placed with native firms for 8ft. and 10ft. span bridges for South India, and for the steel and ironwork for certain footbridge extensions upon the East Indian Railway. Other railway orders, which a few years ago would undoubtedly have been placed in this country, have now been given to native firms.

ACCORDING to a consular report dealing with the consular district of Tainan, South Formosa, the Trans-Formosan Railway was completed between Kelung and Takow in the month of April, 1908, and was officially opened on October 24th by His Imperial Highness Prince Kannin No Miya, who came for that purpose from Tokio. Owing to this completion the service has been accelerated and the express train which runs once a day now performs the journey from Kelung to Takow, a distance of 246 miles, in fourteen hours. Takow to Kyukyokudo, a distance of ten miles, is also now open to traffic. The Trans-Formosan Railway has been ten years in course of construction and has involved a total expenditure of 30,000,000 yen—£3,062,500—the total outlay, contrary to usual experience, having been 1,250,000 yen less than the original estimate. This is owing to the fact that since 1905 the line has been yielding a good revenue. Many sugar mills in South Formosa have laid down light railways of 2ft. 6in. gauge for the transportation of sugar cane and materials, and parts of these lines are in several instances used for public traffic.

ACCORDING to a consular report dealing with the trade and commerce of the Vilayet of Aleppo, the Beyrout-Rayak-Aleppo Railway has proved not to be in a position really to help the development of trade of the Aleppo vilayet. This railway has a length of about 312 miles and is divided into two sections. The first section is a narrow-gauge line and extends from Beyrout to Rayak in the Anti-Lebanon. The other section, a broad-gauge line, starts from Rayak and terminates at Aleppo, passing through Homs and Hama. Aleppo goods have to be transferred at Rayak, where they are exposed to delays and damage. For this reason the port of Alexandretta is still attracting the bulk of the trade, as it constitutes the natural and the most direct port for the Aleppo and Mesopotamian vilayets. The inhabitants of the vilayet of Aleppo, since the proclamation of the Constitution, are strongly and persistingly claiming from the Ottoman Government the prompt construction of the Alexandretta-Aleppo Railway. It seems that the Government have now taken their demands into serious consideration, as there is at present an idea of carrying the main Bagdad line from Adana through Alexandretta to Aleppo. Such a line would no doubt immediately manifest its commercial and economical importance.

NOTES AND MEMORANDA.

THE officer administering the Government of the Gold Coast reports that the output of gold from the Colony, including Ashanti, during the month of May, amounted to 24,173 oz., valued at £94,035, and concentrates £3500 sterling.

ACCORDING to the *Engineering Record*, heating a building with hot water from the jackets of a gas engine is to be tried at Detroit, Mich., in conjunction with a 1400 horse-power engine and producer plant now being built for the Ford Motor Company.

THE discovery of an extensive deposit of fireclay is reported from Monduran Creek, the Narrows, between Gladstone and Keppel Bay, Queensland. The exposed face shows strata of clay extending over a distance of about three chains, while the thickness of the strata from the water level up to the "overburden" of gravel is about 20ft.

WOOD preservation in the United States in 1908 required over 56,000,000 gallons of creosote and nearly 19,000,000 lb. of zinc chloride, with small quantities of crude oil, corrosive sublimate and other chemicals, according to the United States Forest Service. Nearly seven-tenths of the creosote was imported, mainly from England and Germany.

THE recent series of experiments off Toulon to perfect a system of wireless telephony for the French navy appears to have demonstrated that wireless telegraphic emissions are not in any way able to disturb the transmission of messages by wireless telephony. Further experiments are to be conducted with a view to obtaining conclusive proof on this important point.

THE production of petrol in Germany has increased considerably since the year 1875, when the output was 781 tons, valued at £4400. In 1908 the production totalled 141,900 tons, valued at £497,100. The production during intermediate years has been as follows:—1880, 1309 tons; 1885, 5815 tons; 1890, 15,226 tons; 1900, 50,375 tons; 1905, 78,869 tons; 1906, 81,350 tons; 1907, 106,379 tons.

THE *Engineering and Mining Journal* of New York of June 12th states that pipe-line connections have been completed by which it is possible to pipe oil from the Oklahoma wells to New York Harbour. This is the longest pipe-line in existence in the United States, and, indeed, in the world. It is not probable that much oil from the mid-continent district will be brought to the seaboard at present, and the completion of the line seems to be more in the nature of a provision for the future or for emergencies which may arise. Oklahoma has the most active oilfield in the country at present; moreover, its production is increasing, while that of Pennsylvania and West Virginia is decreasing. It may not be long before the western wells will be called upon to supply the seaboard and export demand.

SHELLAC is the most important and largely applied of all the resins with, perhaps, the exception of colophony. Its most interesting use in India is as a method of decorating articles of wood, metal, and even pottery, which are then known as lac wares. These should be carefully distinguished from the lacquered goods largely produced in Europe and America, in which the lacquer is merely a liquid varnish applied to metallic objects, mainly with the object of preserving them from the action of the atmosphere; and from the true lacquer wares of Burma, China, and Japan, where the varnish used is purely of vegetable origin and is applied in a liquid form. In the production of Indian lac wares shellac, suitably coloured, is applied in a solid form, mainly with a view to ornamentation.

WE learn from *Science* that Mr. C. G. Abbot, director of the Smithsonian Astrophysical Observatory, has left Washington for Mount Wilson, California, to continue observations, in progress for a number of years, as to the intensity of the sun's rays and the effect of any variation in them upon the earth. There was recently erected on Mount Wilson a small permanent observatory especially designed for this purpose. Here Mr. Abbot, with the assistance of Dr. L. R. Ingersoll, of the University of Wisconsin, will study during the next few months. The expedition will also spend some time on the summit of Mount Whitney, 14,500ft. high, where the institution proposes to erect in July a shelter of stone and steel for the use of scientific investigators engaged in researches of any kind for which high altitudes, dry air, and clear skies are desirable.

A CONSULAR report dealing with the trade, commerce, and agriculture of the Consular district of Chicago for 1908 states that the production of copper in Northern Michigan was estimated at 113,250 tons, valued at £6,180,000, which was a larger tonnage than in 1907. The price was unusually low, ranging from 5⅞d. per lb. at the beginning of the year, to 7d. at the end, being the lowest since 1894. This field has been worked for 50 years, but none of the mines are showing signs of giving out yet, while several new mines will soon become producers. In Wyoming the copper mines are beginning to be developed. The Michigan mines are now at a great depth and can only be worked in competition with the newer mines by the use of labour and time-saving appliances. Some of the Montana mines are said to produce copper at a cost of 5d. per lb., while it sold during part of the year under 6d. per lb. The exports of copper have fallen steadily for three years, but when the price was lowest, at the end of 1907 and the beginning of 1908, a great impetus was given to export, which has now almost got back to the normal level.

DAKAR is one of the few roadsteads on the West African coast which it has been found possible, without prohibitive expense, to convert into a port. It has, of course, natural advantages, such as its geographical position as a port of call for vessels running to South American and West African ports and the shelter afforded by the Cape Verde peninsula. To convert it into a port, the works designed, on the commercial side, consisted of enclosing the harbour by two masonry moles; constructing two masonry piers, each 325 yards long and 260ft. and 325ft. wide respectively, and quays connecting the piers of a total length of 2235 yards, of which 783 yards have a depth of 26ft. and 1452 yards a depth of over 21ft. alongside; reclaiming nearly 52 acres of ground behind the quays, dredging two basins, one to a depth of 26ft. and the other to a depth of over 21ft. (minimum depth at low springs); and, lastly, providing such accessory works as sheds, landing places, machinery, and a water supply. The work was begun in 1904, and, except for the installation of electric light and cranes, it may now be regarded as practically completed.

IN a recent paper Professor W. H. Watkinson quoted the figures of Mr. Longridge as showing that gas engines are 50 per cent. less liable to breakdowns than steam engines, these figures being obtained from trustworthy insurance data. The figures have so often been accepted as showing the superior reliability of the gas engine as compared with the steam engine, states a contemporary, that it seems necessary to point out that such a comparison is apt to be misleading. In the first place, the average size of the gas engines insured is usually considerably less than that of the steam engines, and large gas engines are notoriously much less reliable than small ones. Indeed, the small gas engine is generally a very reliable machine, and requires but little attention. Our best firms of gas engine makers put their highest efforts into these small machines. On the other hand, our contemporary maintains, the smaller steam engines are not usually so well designed or made, and they are so simple to run that, as a rule, they receive the scantiest of attention. As things are in practice, the small gas engine is probably more reliable than the small steam engine, but the reverse is probably true of large engines. That, at least, is the opinion of many insurance engineers.

MISCELLANEA.

H.M. CONSUL at Palermo reports the formation at Milan of a company for the manufacture at Messina of sulphuric acid from sulphur, and of citric and tartaric acids, cream of tartar, and other chemical products. The company is to have a capital of £40,000, which may be increased to £80,000. Works are to be erected very shortly. The Consul adds that a German chemical company, which is interested in the scheme, is already a maker of citric acid; it is therefore experienced in the manufacture, which is new to Sicily, but which has often been contemplated with a view to utilising the raw material on the spot.

IN the House of Commons recently Mr. Middlemore asked the First Lord of the Admiralty what were the dates of completion originally decided upon for the St. Vincent, Collingwood, Vanguard, and Neptune, and whether it was anticipated that those dates would be adhered to. In reply, Mr. M'Kenna said that the dates were as follows:—St. Vincent, December, 1909; Collingwood, February, 1910; Vanguard, March, 1910; Neptune, January, 1911. It was not anticipated that the Neptune and Vanguard would be delayed, but some delay was expected in the completion of the St. Vincent and Collingwood.

THE *Bulletin Mensuel de la Chambre de Commerce Français de Milan* for June contains some particulars relative to an extensive scheme for enlarging the canal and dock accommodation at Milan. It is proposed to add two branches to the canal and to build six docks. The new enlargements will occupy a space of about three miles. The tonnage at present handled amounts to 500,000 tons per annum, but with the proposed extensions it is expected to rise rapidly to 1,000,000 and even 2,000,000 tons. The cost of the work is estimated at 60,000,000 lire—£2,400,000—and it will take about ten years to complete.

MINERAL oil companies and iron manufacturers who use the recovery process, states the *Chemical Trades Journal*, will be interested to learn that India is likely to become a considerable consumer of sulphate of ammonia. This is in connection with the cultivation of the sugar cane, which is being encouraged in the Bombay Presidency, where experiments for the improvement of the cultivation are in progress. The use of sulphate of ammonia as a fertiliser on cane fields has been established in the West Indies and in Japan. A statement is made that sulphate of ammonia is likely ere long to be manufactured on a considerable scale in India itself.

THE high-pressure pumping station on Delaware Avenue, Philadelphia, has proved so successful that it will be practically duplicated at Seventh and Lehigh Avenues, in the city's mill district. It will contain ten 300 horse-power vertical single-acting gas engines, direct connected to triplex pumps, and a 140 horse-power unit for auxiliary purposes. Fuel gas will be drawn from the street mains, and two large holders in different parts of the city will furnish the supply. Experience with the present plant indicates that any unit can be made ready to pump against 300 lb. pressure in 45 to 60 seconds from the time the signal is received, and the whole station can be put in operation in seven to ten minutes.

AN ascertained commercial value of £4 per milligramme (equivalent to £114,000 per ounce) has been placed upon radium by a contract just entered into for the supply of 7½ grammes (rather more than a quarter of an ounce) of pure radium bromide. This very large order for radium will be supplied from a mine in Cornwall. In the short history of radium production there has never hitherto been known any greater order than a gramme. The world's first order on a large scale will therefore be supplied from a British source, from which several smaller orders have already been supplied. The 7½ grammes of radium referred to are to be presented by Lord Iveagh and Sir Ernest Cassel to the Radium Institute, to the formation of which they have already contributed very large funds.

A CONSULAR report dealing with the trade of Corsica states that the quantity of machinery imported is still unimportant, but a slight expansion is noticeable during the last three years, and he hears that buyers of certain kinds of agricultural machines are not now quite so scarce as they used to be. But the small landowner and farmer—and the small ones form the majority—is extremely conservative and still seems quite content to go on ploughing, reaping, and thrashing in precisely the same way as did his forefathers. The demand for agricultural implements is therefore likely to remain a very modest one for a long time to come. The machines referred to above are light ploughs, ploughs for use in vineyards, harrows, mowers, hoes, olive and wine presses, sprayers—Pulvérisateurs—and weeders.

ONE of the problems to which the Illuminating Engineering Society, founded last month, should address itself is that of the effect of modern illuminants on the sight. Direct illumination by means of gas and other illuminants is rapidly disappearing, giving place to indirect methods, such as the heating of mantles to incandescence by the gas, and to the production of high temperature effects with filaments and arc lights by electricity. With the increase in the temperature of the source of illumination, the *British Medical Journal* points out, the quantity of ultra-violet rays emitted has rapidly increased, and Drs. Schanz and Stockhausen, who are still working on the subject, maintain that artificial illuminants are more trying to the eyes than natural light, owing largely to their very much higher percentage of ultra-violet constituents.

IN the House of Commons on June 17th Mr. Devlin asked the First Lord of the Admiralty whether he was aware that in a yard on the Clyde where a Dreadnought is to be built the maximum wage paid to labourers was 18s. per week of 54 hours, and that in other yards on the Clyde where Government work has been done, the minimum wage for the same class of labourers was 20s. per week; and whether, as the cost of living is the same in all the Clyde districts, he would insist upon all shipbuilders executing Government orders paying a minimum wage of not less than 20s. per week to adult labourers. In reply, Mr. McKenna said that the fair wages clause in the contracts for building his Majesty's ships would be strictly enforced, and, if any information of a detailed character admitting of investigation be furnished to the Admiralty, inquiries would be made and action taken with a view to enforcing the fair wages clause.

IN the interests of miners generally, it is essential that every precaution should be taken to enforce the rules and regulations which have been drawn up, and which have been shown to be absolutely necessary to the safety of the persons engaged in this hazardous occupation. To enable this to be efficiently done requires an adequate staff of inspectors. In the House of Commons recently Mr. Glover, in referring to the matter, contended that the inspection of mines is not carried on in an adequate fashion, and suggests the appointment of twenty-six sub-inspectors, to be chosen from the ranks of the miners. As justification for his proposal, Mr. Glover pointed out that during the last thirty-five years no less than 40,000 lives have been lost in mines, and last year no fewer than 1340 lives were sacrificed. The total number of accidents in 1903 was 6350; in 1904, 6160; in 1905, 5921; in 1906, 6333; in 1907, 8622; and in 1908, 8613. While the Government were not opposed to an increase in the inspectorate, and frankly admitted that in the matter of accidents in mines an irreducible minimum had not been reached, they announced that the Royal Commission which is at present sitting will probably report in favour of an increase of inspectors, and promised that in that case the Home Secretary will press the Treasury for the requisite increase.

QUICK-FIRING FIELD GUNS

(For description see page 650)

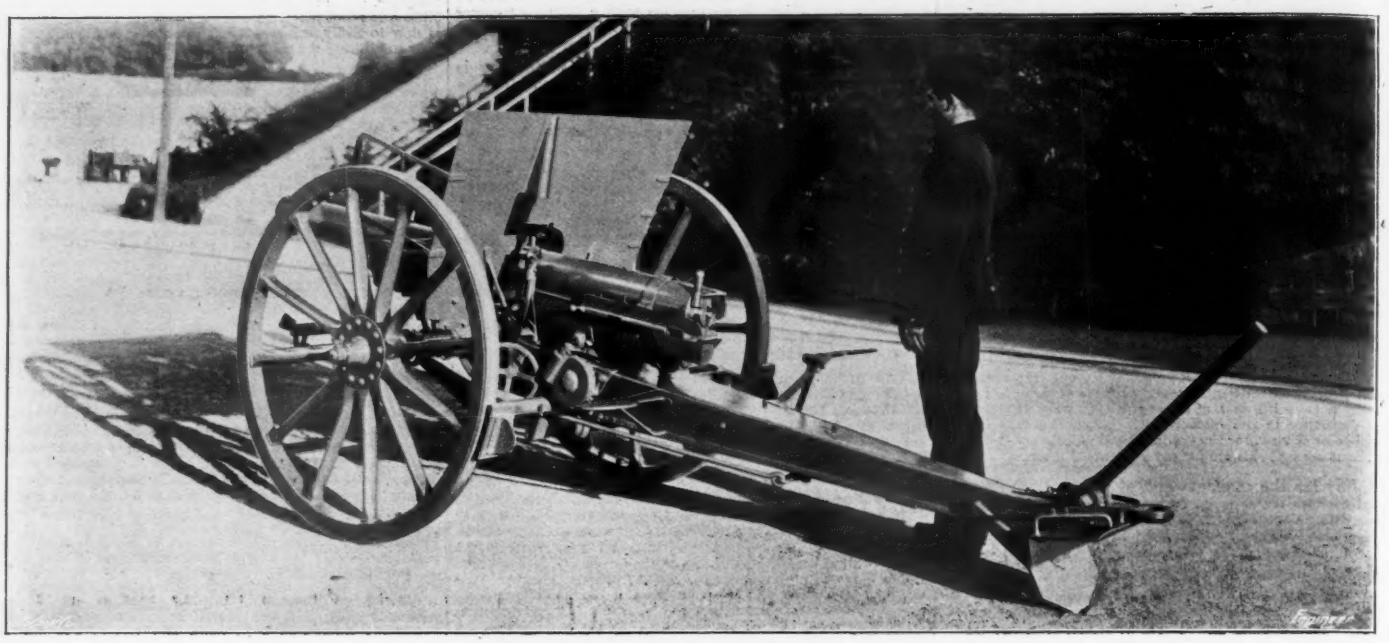


Fig. 6—SCHNEIDER 75 MM. GUN

Fig. 7—BETHLEHEM 3-INCH GUN

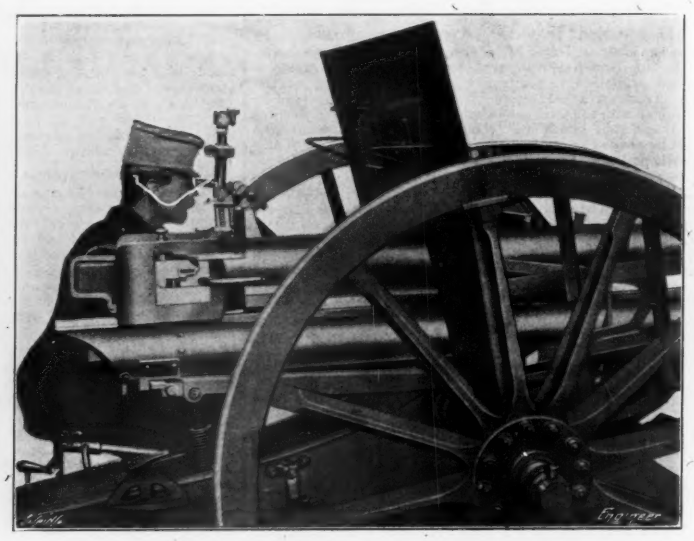


Fig. 8—AUSTRIAN 76 MM. GUN WITH GOERZ PANORAMA SIGHT

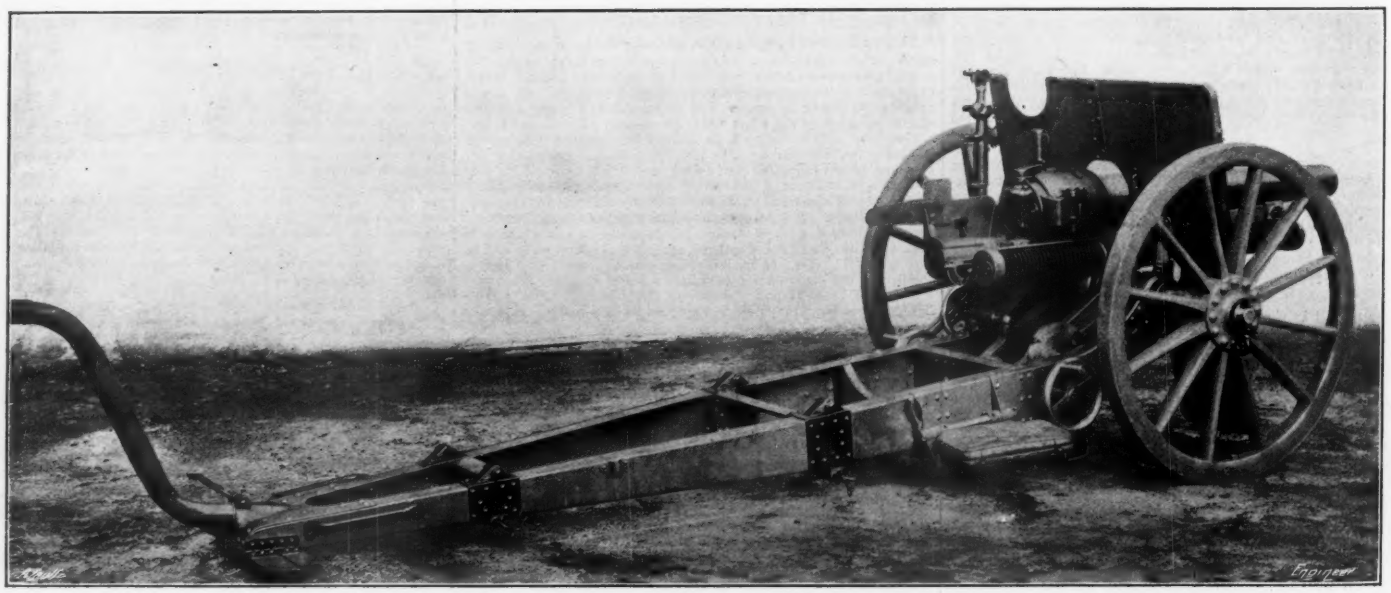


Fig. 9—VICKERS-MAXIM 75 MM. MOUNTAIN GUN

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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MEETINGS NEXT WEEK.

THE JUNIOR INSTITUTION OF ENGINEERS.—Wednesday, June 30th, at 8 p.m., at Fishmongers' Hall, near London Bridge. The Gustave Canet Lecture on "The Engineering of Ordnance" will be delivered by Lieut. A. Trevor Dawson, R.N. Friday, July 2nd, at 7 p.m. Visit the Engineering Workshops and Laboratories of the East London College, Mile End-road, E.

THE ENGINEER.

JUNE 25, 1909.

Ton Miles.

IN 1906, for some reasons not easily explained, the Government yielded to the demands of a very limited number of energetic men and appointed a Departmental Committee of the Board of Trade "to consider and report what changes, if any, are desirable in the form and scope of the accounts and statistical returns—capital, traffic, receipts, and expenditure—rendered by railway companies under the Railway Regulation Acts." The members of the Committee were Mr. A. Clayton Cole (chairman), Mr. William M. Acworth, Mr. Walter Bailey, Mr. G. Stapylton Barnes, Mr. A. Wilson Fox, C.B., Sir Charles J. Owens, Mr. George Paish, the Hon. George Peel, and Mr. G. J. Whitelaw. After three years' labour the Committee has reported. Inasmuch as the Blue-book can be obtained for a few pence it is not necessary to reproduce any part of it in detail. In effect, from first to last, the only point at issue was the value of ton mile and passenger mile statistics. The majority of the Committee report that:—"Except where a very strong demand is made on behalf of the public for certain information, we do not think that public companies can fairly be put to the expense of compiling statistics which have no reference to existing methods of working, and which the majority of the companies still regard, though perhaps erroneously, as useless. No sufficient evidence has been brought before us that any such strong feeling exists, except among a very limited number of persons. Both shareholders and the general public appear, so far as we have been able to judge, to show little interest in the question of the general adoption of ton mile figures, which, so far as this country is concerned, are in use only on a single English railway." Mr. Acworth, Mr. Paish, and Mr. Peel dissent, although they have signed the report with a reservation. This was to be expected, for it is to Mr. Acworth and Mr. Paish that the appointment of the Committee is mainly due.

We have, it will be remembered, always held that ton mile and passenger mile statistics may be not only useless, but also very misleading; and this while we have urged that it would be desirable to know with some precision the number of passengers carried per train. A few of the twenty-nine witnesses examined were in favour of the ton mile statistics; but when pressed for reasons they were unable to cite a single instance in which they had reduced the cost of traffic or effected an economy. We may, perhaps, except Sir Alexander Rendel, who said that they had enabled him to reduce coal rates 20 per cent. on the East India Railway. An important reservation has been made by Sir Charles Owens, Mr. Bailey, and Mr. Whitelaw. This embraces a technical objection to the competence of the Committee, and a particular condemnation of the passenger mile and ton mile system. The following quotations will suffice to show what their views are:—"With regard to the passenger mile unit, it is no exaggeration to say that no evidence has been tendered to the Committee of the value of this statistic as an aid to the efficient working of passenger traffic." The Majority Report contains the following passage:—"Practically no instance has been brought to our notice of any definite increase of earnings or decrease of expenditure in any specific case which was the result of the use of the ton mile figures, and which could not, and ought not to, have been brought about by other means." Sir C. Owens is the general manager of the London and South-Western Railway; Mr. W. Bailey is the chief accountant of the Midland Railway; Mr. G. Whitelaw holds a similar appointment on the Great Western Railway. The value of their opinions is, of course, overwhelming.

It is worth while to consider one or two important points which seem to have been overlooked in this very one-sided controversy. It is admitted that ton mile returns can give nothing but an average obtained by dividing the whole number of miles run by the whole number of tons carried. A principal defect in an average is that it represents very little that happens. Suppose, for example, that we have fourteen quantities of water ranging from fourteen quarts to one quart, and that these are distributed to ten individuals. It is clear that the average distribution is 10.5 quarts, but as a matter of fact only one individual out of the ten gets that quantity; all the others get less or more. Applying this to 100 tons of goods carried a mile, it will be seen that the average may represent only the carriage of a single ton a single mile, and can supply no general standard whatever to guide a railway company. The question is irretrievably complicated by the circumstance that there is no such thing as a uniform scale of charges per mile. A ton of coal is carried at slow speed under conditions of maximum economy. A ton of fish has to be taken to market by special train at 50 miles an hour. In what way could a railway company utilise the average ton mile when the coal train and the fish train are lumped together? The theory is, we believe, that if railway companies possessed ton mile statistics they would load their trains more heavily. The managers could be made aware of the fact that some trains did not carry enough. But it ought to be evident that an average could not indicate what train was run at a loss or what at a profit. To make the system of any value we should require to have the ton mileage of every individual wagon for each year—a thing obviously impossible. The matter of interest for railway companies is not the mileage but the earnings of individual trains. The ton mileage is a matter of no consequence; what does a coal train weighing 700 tons net earn by running from Rugby, let us say, to London? It would be quite useless to mix the mile tonnage of such a train up with that of a train from Dunstable laden with straw hats or from Coventry with bicycles. But the earnings of trains are quite well known by the officials and managers of the railways. The assumption of the outsiders writing for the daily press is that these men do not understand their business, and that they are in dense ignorance of facts with which they are really quite familiar. We can assure Mr. Paish and Mr. Acworth that there is what we may term an inner intelligence department, and an interchange of information and opinions going on daily of the existence of which they are evidently quite ignorant—as, indeed, it is intended that they should be.

Let us suppose, however, that ton mile statistics are supplied to the Railway Clearing House, and made public. In what way are the figures to be criticised? It is clear from the summary of the evidence furnished in the report, that none of the witnesses were prejudiced against the ton mile. What they wanted was direct proof that it would reduce the cost of haulage, or improve the service of trains. The system has been tried; indeed, is now being tried in this country. The Great Western had it for years, and gave it up. The North-Eastern Railway has it, but, the representative giving evidence could not cite a single case in which a reduction in cost of haulage could be referred to its operation. Under existing arrangements very close supervision is used to secure that trains are properly loaded. Take, for example, the Great Central Railway. The starting load of each wagon is recorded, and the average for each station is prepared monthly. The average number of wagons per train is watched in a similar manner, and statements with regard to the loading are placed before the management each month. What more could the ton mile do than this?

Passenger mileage stands on a somewhat different footing, because there is no incongruity in the things dealt with; but the figures are already available. What is far more desirable is the passenger train content—in other words, figures showing how many passengers are carried per train. Here, again, the statistics may be very misleading, and would have to be used with much discrimination. The Committee deal very briefly with this section. They hold in effect that the compilation of the information would be very difficult, and that it would be of little or no value. Mr. Mansfield, representing the Railway Clearing House, said that the work which would have to be done was so much

heavier than that for goods that he had not made any estimate of the cost that would have to be incurred. "Passenger traffic," says the report, "is less under the control of the working staff than goods traffic. Quick and convenient service becomes a consideration of the first importance. While it is possible by means of short delays to increase the loading of goods trains, such methods are, as a rule, quite impracticable in the case of passenger trains. Efforts to secure heavy loads of passengers are apt to involve overcrowding." Locomotive superintendents have long protested against the enormous dead weight now hauled per passenger. It has been replied that the locomotive superintendent knows all about engines, but the traffic manager knows all about the British public. The introduction of the continental system of filling trains would certainly not be popular in this country.

Time and Overtime.

THE debate on the second reading of the Labour Exchanges Bill, which took place on 15th June, was of more than ordinary value. We are told by the daily papers that it was desultory, which we take to mean that some at least of the speakers spoke without that preparation and reserve that are common in full-dress debates. On such occasions truth is more likely to find its way to the top than when the leaders have their men well in hand and each speaker is careful to say nothing which has not beforehand received the approval of his colleagues. For that reason it will be found, if the arguments are examined, that there is great lack of unanimity even amongst the adherents of the Government as to the value of the Bill in question. We have already referred once to this subject, and to-day we shall content ourselves with the single remark that a grave and serious mistake may be made by endeavouring to import foreign labour economics into British industries. The great elements of human nature are the same all the world over, but there are always differences of more or less greatness in the details, for just as all men are constructed on one general plan, but have differences which make it unusual for even two out of many millions to be alike, so with many industries in different parts of the world, though they often are, viewed broadly, almost entirely the same, yet if we look deeper and with sufficient knowledge we shall distinguish many characteristics peculiar to each. It is to be feared that legislators and the general public frequently fail to recognise this fact. To them an industry is an industry no matter where it may be situated. Judgment according to Locke is the recognition of differences, and lacking the power to distinguish these differences these people lack judgment. The knowledge needed can only be acquired by careful and prolonged study. It is not to be won by flying visits to German industrial centres, or a Sunday afternoon acquaintance with a Government Blue-book. Too often such superficial means produce the wrong effect. A hasty view often reveals similarities; it is only careful analysis that displays differences. It behoves us then to consider with the greatest care before we transplant into our own soil, which may be uncongenial, a plan which has been apparently successful in Germany. The importation of foreign methods into this country has not hitherto been eminently successful, and we have no grounds for believing that the adoption of German labour exchanges would meet with a better lot. With that observation on the scheme as a whole we turn to a single item of the debate.

Mr. Pointer, a labour member, is reported to have said:—"The system of overtime, which meant robbing other men of their work, would seriously interfere with any scheme of labour exchanges. It was estimated that 7,000,000 hours of overtime were worked every day, which represented daily employment for 800,000 men. The Government would be well advised to consider seriously the introduction of an eight hours day in all trades. If such a measure were brought in employment would be found for half a million adult workers daily in this country." This remark was greeted with cheers from the Labour Party. We shall overlook the rather wild mathematics, and we shall not challenge the accuracy of Mr. Pointer's estimates. *They* may be right; the principle that Mr. Pointer has at the back of his head is certainly wrong. It is not difficult to see that he regards overtime either as a malevolent act of the employer, or as an evil which might be avoided by taking thought. Now it may be stated without fear of contradiction, that few employers like overtime, for the very simple and obvious reason that it is less profitable than ordinary time. In most trades with which engineers have to do overtime increases the labour cost by 25 per cent., in none by less that 12½, and in certain cases by 50 or even 100 per cent. Overtime is an ill which is only tolerated because the alternatives are worse. Those alternatives are, in the first place, reduction of dividend with ultimate loss of trade, and in the second, increase of works and plant, with all the standing charges appertaining to them. We wonder if Mr. Pointer has ever endeavoured to estimate, even roughly, what the total prohibition of overtime in a moderate sized engineering works would mean. It may be useful to glance at the items for a moment. We shall, of course, exclude factories where two or more shifts are in regular operation, and consider the case of an ordinary ironworks employing, say, one thousand men. In times of bad trade, as at present, half that number is employed, in good times the full complement, and under pressure one or more departments work an extra two hours a day. Let us take now the machine shop. It is large enough for the normal demand, but Mr. Pointer asks us, in order to avoid overtime, to increase it above its requirements. In that shop there is a tool which cost £500. In a 54-hour week it cannot do all that is required of it; in 64 hours it can. If it may not be worked the two hours' overtime for five days a week another machine of the same size must be put down. To be profitable the two machines should work 108 hours, actually they only work 64—that is to say, that one machine must stand idle for approximately 80 per cent. of its time. That is under the best conditions, when overtime is required; under normal conditions, which prevail possibly for half the year, the machine is doing nothing at all. Taken over the whole year, then, the extra tool is working one hour per day instead of nine. Now, the original cost was £500, but we must not imagine that is an end to the charges involved. Besides this capital sum £35 or so per year must be written off for depreciation, and at least £10 for insurance, upkeep, and so on, even when the machine is idle. On top of this shop space has got to be found for it, and shop space means ground rent with rates and taxes. Furthermore, a dividend must be paid on the original £500 if the machine was purchased out of capital. We have taken a single machine of medium price; let the same form of calculation be applied to a whole machine shop, and we shall see at once that the problem becomes exceedingly formidable. Indeed, we need not hesitate to say that it would spell ruin to many concerns. It would mean that in order to avoid casual overtime a large and costly plant would have to lie idle, or be used unprofitably, for a great part of every year. Mr. Pointer will tell us that there is a simple alternative; if you have as much work as you can undertake in ordinary working hours refuse to accept any more. In theory that sounds plausible, but if Mr. Pointer will try to work it out by actual management of a shop he will find that it is impracticable. To consider the various cases that may arise to overthrow such well laid schemes would take us into far issues and is unnecessary; we should not convince Mr. Pointer, and those who have experienced the difficulties are already convinced. The general fact, of course, is that a certain measure of elasticity is essential to the welfare of every business. Even the Coal Mines Act has recognised that, and permits an extra hour to be worked on sixty days of the year. Overtime is precisely the equivalent of overload; no engineer could, or would, work his generators continuously at their ultimate output, yet he invariably specifies that they may be able to carry for a certain time a certain percentage in excess of the normal load. That is recognised as sound commercial engineering practice, and in the same way overtime must be recognised as equally sound and necessary.

It is to be feared that the simplicity of an argument like that used by Mr. Pointer leads many people astray. It looks so extremely innocent and straightforward. You take the whole number of hours of overtime worked per day, and you divide by eight, the length of the proposed statutory day. The result is supposed to represent the number of people that could be employed under improved conditions. The argument is, of course, fallacious. Apart from the fact that it jumbles all sorts of trades together, it leaves out of account entirely the fact that now-a-days the bulk of industry depends upon mechanism and appliances of various kinds and factory space, and it is because these are lacking that a large proportion of overtime is worked. When, furthermore, it is remembered that often enough the amount of overtime required is not enough to take a man's whole time, it will be seen that there are obstacles in the way of Mr. Pointer's scheme which are not to be overcome in the ordinary workaday world, and we may safely assert that any unemployment scheme which has for its foundation the entire prevention of overtime is doomed to failure.

The Crawford Derailment.

ON the 2nd of April a remarkable accident occurred on the Caledonian Railway near Crawford Station, about 56 miles north of Carlisle. It attracted a good deal of attention at the time, the fact that there was no loss of life and very few injuries inflicted being very remarkable when all the circumstances are kept in mind. Colonel Yorke's report to the Secretary of the Board of Trade has just been made public. The train was the 2 p.m. down express from Euston to Glasgow, leaving Carlisle at 8.13 p.m. The accident occurred at 9.30 p.m. The engine was one of Mr. McIntosh's large inside-cylinder engines with six-coupled drivers and a four-wheeled bogie. The leading driving wheels are on the crank axle, and represent nearly 19 tons, the second pair 18 tons, and the third 17 tons 10 cwt. The total weight of the engine is 73 tons, and that of the tender 57 tons. The train consisted of nine heavy vehicles, two of them being dining saloons. While the train was running at sixty miles an hour down 1 in 240, the crank axle broke off short just inside the boss of the left-hand wheel, the coupling-rod broke, and the engine and tender parted company. As the brake gear and reversing gear were smashed, the engine, which kept the rails, ran about three-fourths of a mile before it stopped. The driver and fireman, who were both luckily on the engine at the moment, escaped without injury. The wheel ran along the side of the line for about 110 yards, and was found leaning against the fence. The derailment took place in a shallow cutting. After the engine broke away the tender was thrown across the line, and every coach left the road either to the left or the right. The great strength of the steel underframes, and the cutting, prevented a destruction that must have caused a fearful loss of life or limb.

The circumstances are, we have said, very interesting. It appears that the coupling-rod broke close to the pin of the intermediate wheel, thus entirely releasing the driving wheel from the engine. The rapidity with which the fracture of the axle and rod must have taken place is evidenced by the almost incredible fact that the wheel—presumably trailing the rod—careered down the line on its own account for over 100 yards, ran up the narrow cutting, and came to rest against the boundary fence. This is the official report; it is supported by no published evidence, and, frankly, we find it very difficult to credit. Moreover, if the wheel and rod could have parted from the engine so easily, the great damage done to the engine itself is unaccountable. Both the main frames were twisted and bent; three trailing cheek blocks, one driving and one intermediate hornblock, brake hanger brackets on the left side, back platform, buffer plate, safety chain brackets, three sand boxes and brake gearing were broken; the left angle iron and platform on the left side damaged. The intermediate and trailing wheels were slightly shifted on their axles. The reversing shaft brackets were broken and an arm twisted; the reversing rod also was broken. It is difficult to understand how all this harm was done while the engine kept the rails. No doubt the broken end of the crank axle was prevented from dropping far by the keep of the axle-box; but the number and diversity of the various stresses brought to bear baffle all attempts to trace each injury to its own specific cause, and leave us in doubt that the sequence of events was as simple as Colonel Yorke thinks. There is no sufficient reason adduced for the parting of the engine and the tender. Colonel Yorke says it was due to the engine lurching when the wheel came off. But so long as the engine kept the rails, as it did, no lurch could have not only broken the coupling, but flung the tender across the road. The derailing of the train is left unexplained. It is said that the flaw in the axle was an old one, but we are also told that the surface of the metal was bright. It would be by no means difficult to explain the catastrophe as the result of a broken rail.

While doubt may exist as to how the axle was broken, the reason why the axle broke is not far to seek. There was a flaw in it which extended over more than half of the sectional area of the metal. The axle had been in use about two years and ten months, during which time it had run over 145,000 miles. It was a built-up axle of nominally 34-ton steel. The extension, contraction, and bending tests

were satisfactory at the time the steel was accepted. But tests of the broken axle did not maintain the reputation of the steel. A report from Mr. Blackadder, of the Glasgow and West of Scotland Technical College, gave the ultimate strength as 30.5 tons, and the elongation in 3in. only 6¼ per cent. This is very different from the 27 per cent. extension in 2in. of the original test. It was impossible to find a flaw without taking off the wheel. All the parts of the axle seem to have been put together with a hydraulic pressure of about 99 tons, or over 10 tons per inch diameter of axle. Mr. McIntosh's evidence differs a little from that of his inspector's at the makers' works, who, it will be remembered, dealt only with the rough forgings. At the Caledonian Company's works a test made on the 5th of February, 1906, "gave 36 tons per square inch with 30 per cent. elongation on 2in. The shaft has broken a half inch inside the boss of the wheel, and the fracture runs along the step of the shaft. The axle in the wheel is 8½in. in diameter, with the exception of the half-inch, which was 9½in. The fracture shows that it had been growing gradually for some time, but it is impossible to say how long. We propose to test the broken axle mechanically and chemically. Such a flaw as this could not be detected by ordinary examination, and could only be seen when the wheel was taken off. We have had axles of this description and of these dimensions running for at least ten years with very satisfactory results; in fact, it is the standard axle for our express engines. Out of 501 axles of this description we have had one failure similar to this. On that occasion the train was not derailed and no damage was done." Now chemical and microscopic tests were made, and the particulars are appended to the report. It may be argued that the deterioration recorded as we have seen was due to fatigue. But the report of Mr. Primrose on the micro sections is that "the axle has been made of inferior metal, which had been left in an overheated condition and suffered from fatigue in use." That is to say, if the metal had not been inferior it would not have suffered from fatigue as it did. Indeed, the micro sections show a brittle structure due to overheating, or incomplete mechanical treatment, We are quite unable to reconcile the tests. Have we here another example of the great difficulty always encountered in endeavouring to arrive at the true inwardness of steel.

Be the inconsistency what it may, there is very good reason to think that the axle would not have broken if only the sharp corner, where the diameter changed from 8½in. to 9½in., had not existed. On this point we are completely in accord with Colonel Yorke. The evil influence of these sharp angles has long been recognised, and need not be dwelt upon here. One question remains for consideration. Is it certain that the axle broke before the coupling rod? It is, we think, worth while to submit the broken rod to the same tests, microscopical and chemical, as those which have supplied useful information concerning the axle.

Coal Trade Troubles and Foreign Competition.

THE differences which have arisen between the coalowners and the miners in South Wales respecting the conditions under which the Coal Mines Regulation Act, 1908—the Eight Hours Act—is to be set in operation next month threaten to involve the Principality in a disastrous stoppage of work. Apart from the mines in Northumberland, where the Act does not come into force until next January, it is stated that temporary arrangements are being made in other parts of the country, one of the conditions being that no reductions in wages shall take place. Nevertheless, the whole question of the Act has now been extended, under the auspices of the Miners' Federation, into one of a national character, whilst the wages dispute between the Scotch coalowners and the men has also been brought within the scope of the Federation. The latter is approaching the representatives of the coalowners with a view to the holding of a joint conference to consider the general questions raised by the Act. The present difficulties, which were foreshadowed in the House of Commons when the measure was under discussion, have already been anticipated to some extent in France under the Act of June 29th, 1905, limiting the hours of labour in coal mines by a gradual process of reduction. Under this Act the second stage, lowering to eight and a-half hours the length of the working day for underground hewers, came into operation at the beginning of 1908. But according to the recent report of the General Association of French Coal wners—Comité Central des Houillères de France—the coal miners in the Loire demanded more than the law authorised, and the colliery owners felt constrained to give way in order to obviate a stoppage at that time. The men secured an additional reduction of a quarter of an hour in the length of the working shift, thus partly anticipating the date when the third stage restricting the hours to eight would be automatically applied. On the other hand, the Miners' Federation of Great Britain, while accepting that portion of the Coal Mines Regulation Act which relates to eight hours, seeks to evade Section 3, which provides that the time may be extended as respects any mine by the owner, agent, or manager, on not more than sixty days in any calendar year by not more than one hour a day. Thus the miners in the Loire obtained an advantage prematurely, whilst the claim put forward on behalf of the British miners also represented an attempt to secure an advantage by shirking one of the responsibilities of the Act.

The prospect of a cessation of the production of coal in a large area in South Wales and in Scotland is specially welcome in the west of Germany, where the course of events has been followed with particular interest during the past few weeks. The Teutonic producers in the Ruhr, as represented by the great Rhenish-Westphalian Coal Syndicate and the 335,000 coalminers employed in that region, see the possibility of securing compensation for the inroads which British competition has made in recent months in consequence of the increased difficulties under which the German export trade has been conducted since last October. A few years ago British coal exporters made strong complaints of the encroachments of Teutonic coal in French and other markets in Continental Europe, owing particularly to the exceptionally low railway rates granted by the Prussian railways for export consignments; but the position has been reversed since last October by the abolition of most of these exceptional rates in order to retain the native production for domestic consumers as far as possible. If such a measure had been adopted when a comparative scarcity of coal prevailed in 1906 and 1907 its object could have been fully appreciated, but it is incomprehensible, in the opinion of the Rhenish-Westphalian Coal Syndicate, at a time when the latter finds a difficulty in effecting sales, and is only raising 85 per cent. of the possible production of the syndicated pits at the present time. The immediate effect of the introduction of higher railway rates to France, Belgium, Switzerland, and Italy has been a reduction in the deliveries forwarded by the syndicate by rail, whilst the position of affairs has been aggravated by increases in rates made by the Swiss railways on the one hand and by lower rates by the French railways on the other for the carriage of British coal from Boulogne, Calais, Dunkirk, and Gravelines to Delle station on the Swiss frontier. If it were thought that the German complaints were exaggerated all doubt on the question is apparently dispelled by the considerably larger tonnage of British coal which has been exported to Belgium, France, and Italy in the first five months of the present year, France, of course, including any tonnage forwarded to Switzerland in consequence of the special facilities afforded by the French railways for this particular purpose.

It will in the circumstances be quite understood that any stoppage in South Wales would be eagerly seized by the Rhenish-Westphalian Coal Syndicate as an opportunity for recovering ground lost in recent months, whilst in the event of the Scotch miners resisting the coalowners' decision to reduce wages below the six shillings per day which the men claim as a minimum, it is stated that the syndicate is prepared to deliver Westphalian coal on the Scotch coast at comparatively short notice. It would, perhaps, not be the first time for coal to reach Great Britain from that region, for apart from the coke supplied on the North-East Coast, two or three cargoes of Ruhr coal were reported to have been sent to the Thames on the occasion of coal trade troubles about fourteen years ago. Everything has changed during the course of the intervening years, and the Westphalian Coal Syndicate now possesses a wonderfully equipped organisation for the promotion of its export trade, and also for effecting transactions in British coal when deemed desirable or necessary. The diversion of some business from Welsh coalowners to Westphalia is reported to have already taken place in the past two or three weeks, and there would probably be nothing impossible in the shipment of Ruhr coal to Scotland or even to the North-East Coast if necessary. Even if no profits were directly realisable on the shipments, each cargo would assist in reducing the total working expenses of the syndicate, which now amount to 8 per cent. of the value of the coal invoiced to it by the pits for sale, whilst each cargo would tend to reduce the standing charges of the pits themselves. All the circumstances point to the fact that it lies in the best interests of British coalowners and miners to meet in joint conference to settle all matters of difference which have arisen from the introduction of the Eight Hours Act, without having recourse to extreme measures on either side. But if the question is to be fought out as an industrial dispute, it would be preferable for the welfare of both parties and for coal consumers in general for the stoppage to take place soon rather than at the end of the year.

OBITUARY.

GEORGE FREDERICK DEACON.

THE death is announced as having taken place very suddenly on the 17th inst. of Mr. George Frederick Deacon, M. Inst. C.E. Mr. Deacon's name will always be chiefly connected with the scheme for taking water to Liverpool from Lake Vyrnwy, which, we believe, he was actually the first to propose, and which he certainly had a large share in carrying out. He was born at Bridgwater in July, 1843, and had, therefore, nearly completed his sixty-sixth year at the time of his death. His father, the late Mr. Frederick Deacon, was a solicitor. Young Deacon obtained his first education at Heversham, and afterwards attended Glasgow University. It is interesting to note that this University in after years conferred on him the title of honorary LL.D.

At the age of twenty-two he commenced practice as an engineer in Liverpool, and almost immediately afterwards accompanied Lord Kelvin—Professor William Thomson as he then was—on the Great Eastern, when, in 1865, an unsuccessful attempt was made to lay an Atlantic cable. On his return Mr. Deacon continued his practice in Liverpool until 1871, when he was appointed borough and water engineer to that city. The fact that a young man of but twenty-eight years of age was entrusted with these important offices gives some indication of the ability which even at that early age he possessed. Nor was the trust misplaced, for he carried out his duties for eight years with distinction. During this period two things stand out clearly among a number of others. We will mention what is, perhaps, the lesser first, though it is far from being unimportant. We refer to the reduction in the waste of water which was brought about by the invention and application of his differentiating waste-water meter. The principle on which this instrument works is that when the water passing through a main is due only to waste—as, for instance, at night time—the amount flowing will be constant. If, then, a pencil, the movements of which indicate the amount of water passing, be made to trace a line on a paper placed round a slowly revolving drum, the line produced when only leakage water is flowing will be horizontal, and the amount passing to waste may be computed. Then, by a series of trials, the point, or points, where waste is taking place, may be discovered. If such an instrument be placed in a given main supplying so many houses, and if in turn each house connection is shut off at a noted time, it is possible to tell not only in which house or houses waste is taking place, but also whether or not the main itself is defective. Of such a character was the instrument devised by Mr. Deacon in 1873. It was first tried in Liverpool, and met with great success.

His connection with the Vyrnwy scheme is, however, the leading feature of Mr. Deacon's life. During the years 1876-77 he was engaged in his office as water engineer in the discovery of a source from which Liverpool could augment its water supply. His investigations covered a large area, including parts of the Lake District and of North Wales. Eventually he decided on the river Vyrnwy. In order to have more time at his disposal for the elaboration and perfection of this great scheme he resigned the position of borough engineer in 1879, and was engaged until 1885 in carrying out part of it, working for the last four years of this time in conjunction with the late Mr. Thomas Hawksley. The years 1885-1892 were occupied by Mr. Deacon in completing, as engineer-in-chief, the first portion of this undertaking which cost, we may mention, two and a-half million pounds sterling. It will be of interest, perhaps, if we give briefly the principal characteristics of the Vyrnwy scheme. The storage lake formed by the dam is 67½ miles from the old reservoirs at Prescott, and covers an area of 1121 acres, having a length of nearly five miles. The water level is at a height of 825ft. above sea level. The dam is straight, and its maximum height above foundations is 136ft. It is 1350ft. long on the top. Its width at the base is 117ft. 9in., and at the top 20ft. When full the reservoir formed by this dam has a capacity exceeding 12,000 million gallons.

In 1890 Mr. Deacon commenced practice as a consulting engineer in Westminster, and he has been connected with a great many important water schemes during the period between then and now. He frequently gave evidence as an expert before Committees of the Houses of Parliament. He was a member of Council of the Institution of Civil Engineers and a member of the Institution of Mechanical Engineers. He was also a Fellow of the Royal Meteorological Society. From the first-named body he had received the Telford, the Watt, and the George Stephenson awards. He was president of the Association of Municipal and County Engineers in 1878; of the Engineering Section of the Sanitary Institute in 1894; of the Mechanical Science Section of the British Association at the meeting in Toronto in 1897; and of the Engineering Section of the Royal Institute of Public Health at the meeting at Liverpool in 1903. The best known of his published writings is perhaps the article on water supply in the ninth edition of the "Encyclopædia Britannica."

EIGHT-CYLINDER COMPOUND SINGLE-ACTING ENGINE

THE NEW LOWCA ENGINEERING COMPANY, LIMITED, WHITEHAVEN, ENGINEERS

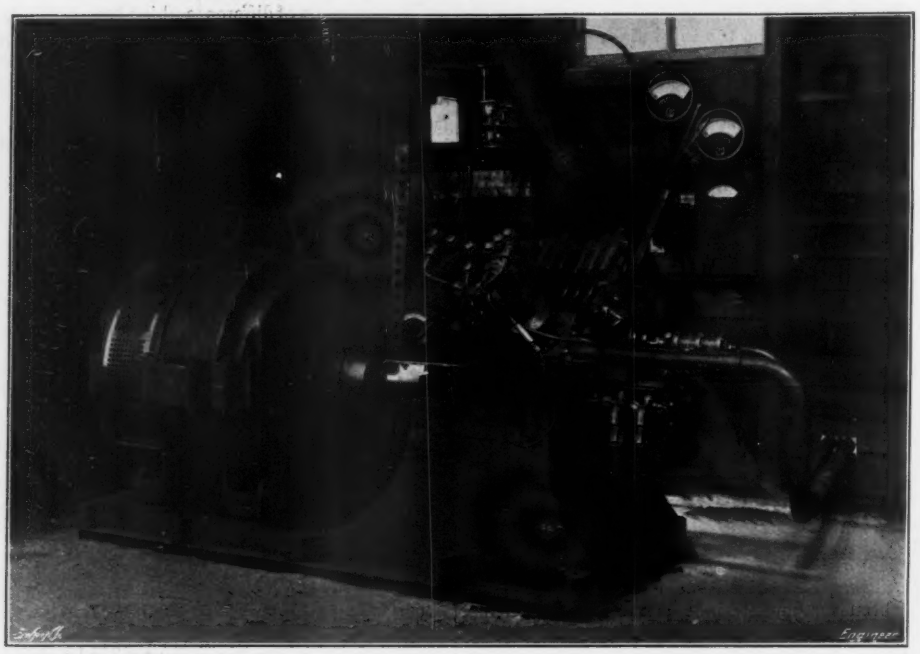


Fig. 1

A NEW STEAM ENGINE.

SOME disappointment was caused at the trials of military tractors held at Aldershot in March last by the non-appearance of a steam propelled vehicle entered by the New Lowca Engineering Company, Limited, Whitehaven, as it was known that the design of this machine embodied more features of originality than were to be found in the other competing machines. The time which the War-office officials allowed for the completion of the tractors, however, was insufficient in the case of the Lowca Company's vehicle, and the company very wisely decided to stand out rather than run the risk of failure with a hurriedly constructed and practically untried machine. One of the most noteworthy features in this tractor is the steam engine, which has been constructed in accordance with the patents of Mr. Harry Bentley, and on Friday last we were invited by the makers to pay a visit to their works at Whitehaven in order to witness tests of the engine carried out on the testing stand. Fig. 2 represents sectional views of the engine, and Fig. 1 shows the arrangement of the testing set, including the electric generator, ammeter, volt meter, speed indicator, &c. As will be observed from the drawing, the engine is of the V type, and has four pairs of cylinders arranged tandem compound fashion, so that with a comparatively simple two-crank engine a great range of expansion is effected, the cranks being set at 180 deg. The engine is single-acting, and the bearings are therefore always in thrust, thereby avoiding the necessity for adjustment.

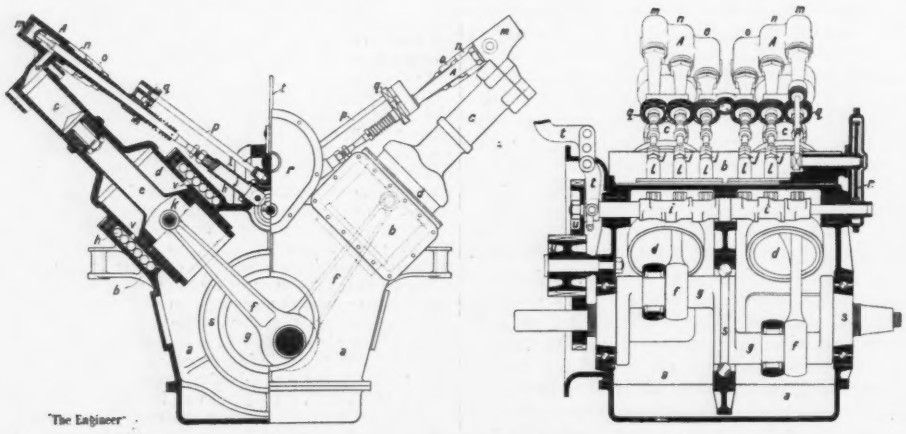


Fig. 2—SECTIONAL VIEWS OF THE ENGINE

Referring to the sectional drawing, the valve chambers are represented by the letter A, the crank case by *a*; *b* are the exhaust boxes, *c* high-pressure cylinders, *d* low-pressure cylinders, *e* pistons, *f* connecting-rods, *g* crank shaft, *h* feed-water coils, *i* cam shaft, *j* pushers, *k* crossheads, *l* pusher guides, *m* steam valves, *n* exhaust valves, *o* auxiliary valves, *p* worm spindles for valve turning gear, *q* spur gearing, *r* spur drive for valve turning gear, *s* ball bearings for the crank shaft, *t* reversing gear, *u* drive for the cam shaft, *v* exhaust ports in the low-pressure cylinders, *w* steam port in the high-pressure cylinders.

The high-pressure cylinders in the engine shown under test are 2in. bore, and the low-pressure pistons 5in. effective area, after deducting the area of the high-pressure trunk, the stroke of both being 4in. It will be noticed that the steam distribution is effected by a single cam shaft and poppet valves on the lines of the petrol engine, but that positive means are provided for causing the valves to revolve so that they re-seat themselves continuously in fresh positions. It is claimed that this feature enables a steam-tight seating with this kind of valve to be maintained. The valves and seatings are conical, and made of a special nickel-copper-iron alloy. The valve and stem are made in one piece, the stem being provided with grooves for lubrication.

The engine can be instantly altered from compound to simple working, and the full boiler pressure admitted to the low-pressure cylinders, if necessary for rapid acceleration, by an endwise movement of the cam shaft, which, when in its extreme position, can hold up the high-pressure valves and thus transform the high-pressure cylinder into a prolongation of the steam pipe. This is a simple arrangement, involving the use of no extra parts or valves as in other compound engines. The whole of the bearings, both of the cam and crank shafts, are of the ball pattern, with races having loose internal and external bearings to render them easily removable. The high and low-pressure cylinder of each unit are cast in one piece of a special grade of cast iron, and to the steam-tightness of the pistons—which are also of cast iron—has also been given special consideration. The method of securing the rings in the high-pressure piston is shown in the sectional view. Although in experimental work steam temperatures in the neighbourhood of 1000 deg. Fah. have been employed, we are informed that this arrangement gives perfectly steam-tight surfaces.

Another feature which, though not novel, is somewhat unusual except in Willans engines, and in the Knight petrol motor, is that the final exhaust takes place through circumferential ports in the low-pressure cylinder. In the annular chamber surrounding the low-pressure cylinder Mr. Bentley has placed a coil of feed-water tubes, so that the feed to the boiler can be raised in temperature by the waste heat from the exhaust steam. The results obtained with the engine fitted to the tractor have been remarkably good.

For the bench test the oil burners under the flash boiler were lighted, the steam raised, and the engine started against its load, which in this instance consisted of electrical resistance. As soon as the full load indicated by 95 ampères and 220 volts—33 net brake horse-power—was attained the water and fuel tanks were filled and the test started and continued for thirty minutes. The engine for the first fifteen minutes ran at a speed varying between 700 and 760; the steam pressure was 490 lb. per square inch, and the temperature 690 deg. Fah., and the electrical output 18,700 watts. For the second fifteen minutes the speed varied between 700 and 770 revolutions per minute, the steam pressure was 500 lb., and the temperature 720 deg. Fah. The fuel used was ordinary paraffin, called No. 1 burning oil, supplied by the Pumpherston Oil Company, and amounted to 24 lb., and the water converted into steam in the flash boiler 220 lb.

Results.

Total mean, watts	19,550
Mean brake horse-power	32.65
Steam consumed	13.5 lb. per brake horse-power
Oil fuel consumed	1.46 lb. " "
Evaporation	9.2 lb. of water per lb. oil

Taking the calorific value of paraffin at 19,000 British heat units, the boiler efficiency came out at 0.69.

The tractor in which the engine is to be fitted will have several distinctive features, including a flash boiler of new design, oil burners, road wheels, 7ft. diameter, of special construction, two speeds, and substantial hauling gear. It has been fitted with a fuel tank and a huge water tank and ample condensing surface. In tests which, we understand, have already been carried out on the roads, the results have been extremely satisfactory, practically all the water which was converted into steam being condensed and returned to the tank.

SOME EXPERIMENTS WITH INDUCTION MOTORS.

THAT polyphase motors of both the induction and synchronous types overheat when supplied from circuits in which the ideal conditions of voltage balance and phase angle are not maintained is well known. In order to determine definitely the performance under other than ideal conditions, and to ascertain the point at which overheating commences, a series of tests were recently carried out in America under varying conditions of voltage unbalance, unsymmetrical angular relations between phases, and combinations of these two, and the results of these tests are dealt with in a paper presented to the American Institute of Electrical Engineers by Messrs. S. B. Charters and W. A. Hillebrand.

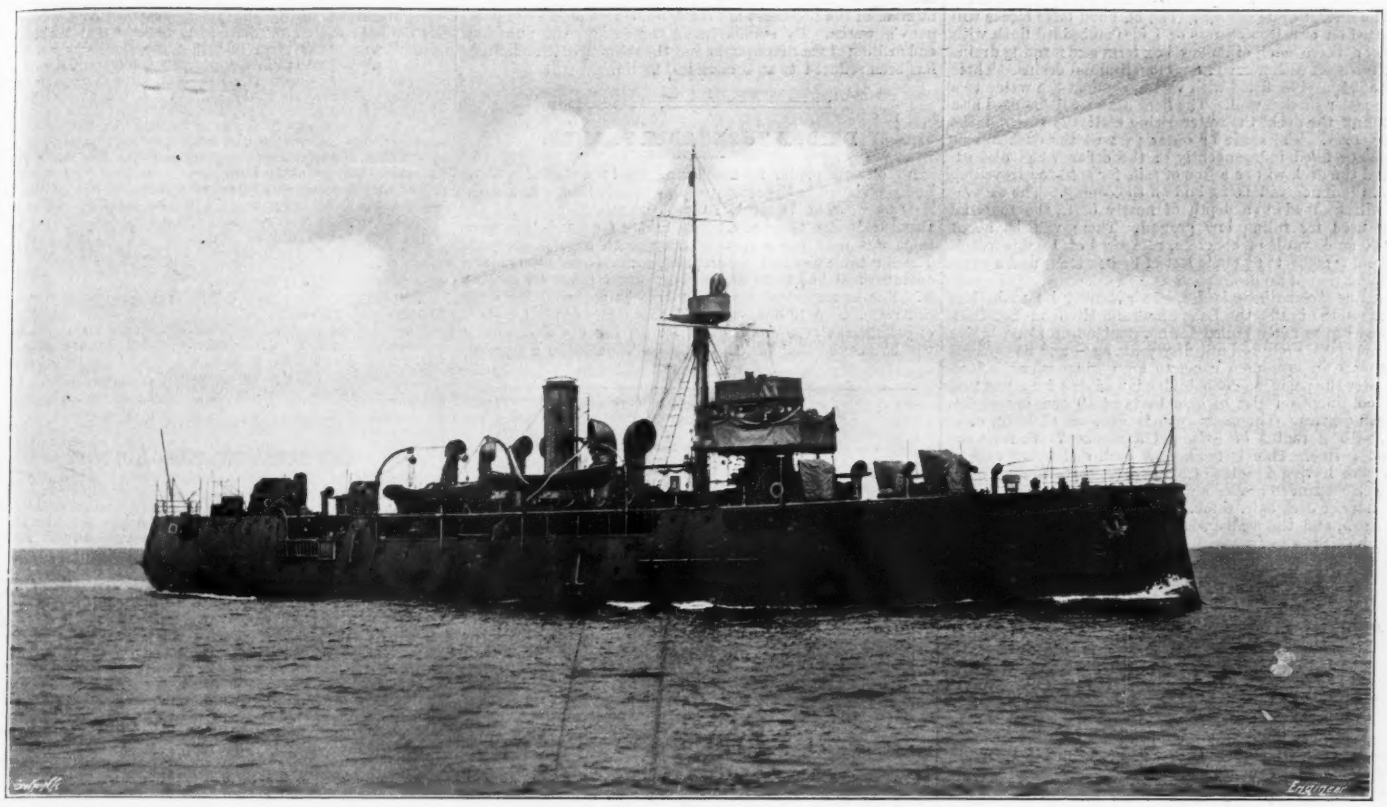
The operating limit of a motor, as determined by the temperature rise in any one phase, is reached when the current in that phase has attained its normal full-load value. In these tests the motors were loaded under varying conditions of voltage unbalance and phase displacement, until the normal-rated current was reached in one phase, when the output at that point was determined. Curves were then plotted, showing the relation between the output at this point and the percentage of voltage unbalance and irregularity of phase difference. The pressure in the phase having the highest voltage was maintained at normal value throughout. The percentage of voltage unbalance is defined as the difference between the maximum and minimum voltages, divided by the maximum voltage, whether operating two or three-phase. Power was supplied by a two-phase 60-kilowatt induction alternator with voltage regulators in each phase and through two 10-kilowatt transformers. Three phases were obtained from the Scott connection. By means of the voltage regulators and various taps on the transformers any degree of unbalance could be obtained. When operating two-phase, the phase angle of one of the applied pressures was shifted by combining with it a pressure from a quadrature source. This connection also unbalanced the voltage, but when desired the two voltages could be brought to equality by means of regulators at the generator. From any three-phase star or delta connection wherein the vector sum of the electro-motive forces is zero, it is impossible to obtain unbalanced voltages without a shift of the phase angle as well, so that in the three-phase runs no attempt was made to separate these factors.

The extent to which reduction in capacity is caused by voltage unbalancing is clearly brought out by means of curves. In the case of three commercial motors differing in type, voltage, and rating, a voltage unbalance of 10 per cent. caused a reduction in output of 40 per cent. The worst performance of all is that of a 2 horse-power 110-volt motor in which an unbalance of voltage of 10 per cent. caused a reduction in output of 54 per cent. Voltage unbalance, however, is not the only factor to be considered in the case of two-phase motors, for departure of the supply voltages from the quadrature relation or phase shift has an even greater effect. A departure of 5 deg. from the quadrature relation in one case caused a loss of output of 26 per cent.

A test carried out on a synchronous motor was performed in exactly the same manner as with the induction motors, except for the fact that the field excitation of the former was adjusted at every observation, so as to give minimum current in the phase having the highest voltage. Attention is called to the similarity between synchronous and induction motor performance in that the reduction in capacity, due to either phase shift or voltage unbalance, varies in both cases approximately according to a straight line law, and that shift of phase is a much more serious factor than voltage unbalance. The synchronous motor, however, differs materially from the induction motor in its behaviour under conditions of combined phase displacement and voltage unbalance, in that the two effects seem to neutralise one another, and an improved performance results. The general conclusions arrived at in the paper are:—(*a*) Unbalancing of voltage and shift of phase tend to cause serious overheating in polyphase motors; (*b*) where it is possible to separate the effects due to phase shift and voltage unbalance, phase shift is found to be relatively of more importance; (*c*) the reduction in capacity, due to either phase displacement or voltage unbalance, varies with the cause approximately according to a straight line law; (*d*) in the induction motor the existence of phase shift and voltage unbalance causes a worse performance than would be expected from either irregularity alone, whereas in the synchronous motor the reverse is true; (*e*) the performance of the induction motor, supplied from an unbalanced circuit, is materially affected by its design; and (*f*) the commonly accepted statement that the torque of an induction motor varies as the square of the voltage, should be changed to read "varies directly with the voltage," in order to make it more consistent with conditions of ordinary operation.

ROYAL SOCIETY OF ARTS.—The Council of the Royal Society of Arts, with the approval of his Royal Highness the Prince of Wales, President of the Society, have awarded the Albert Medal of the Society for the current year to Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S., "in recognition of his long-continued and valuable researches into the nature and action of explosives which have resulted in the great development and improvement of modern ordnance."

THE ARGENTINE GUNBOAT PARANA

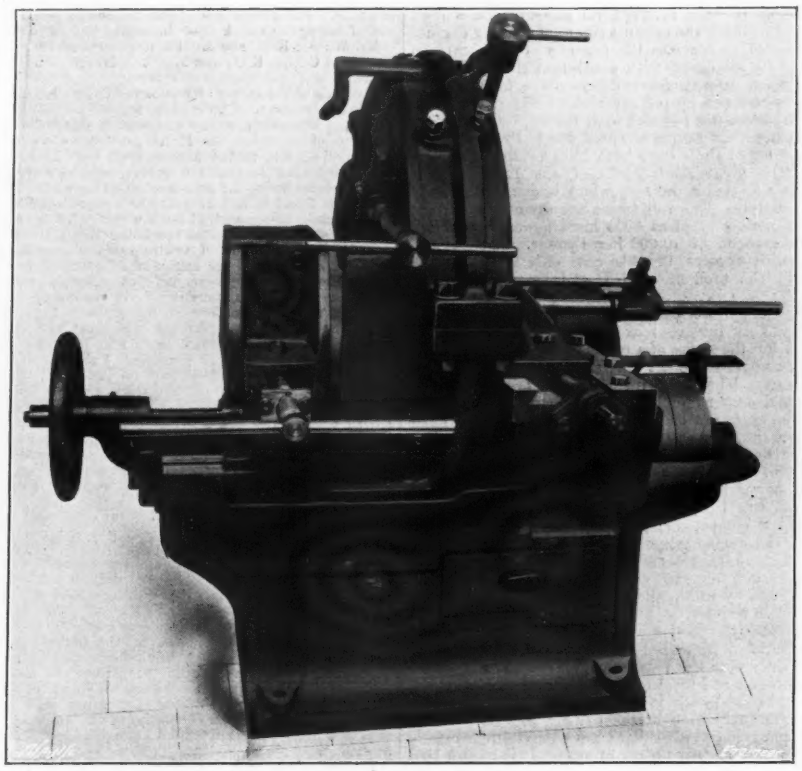


THE ARGENTINE GUNBOAT PARANA.

THE armoured gunboat Parana, built for the Argentine Government, which was launched from the Elswick shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited, in April of last year, has just recently successfully completed an exhaustive series of speed and other trials. The Parana has a length over all of 250ft.; a length between perpendiculars, 240ft.; a breadth, moulded, 22ft. 3in., and depth, moulded, 14ft., and a mean draught, 7ft. 6in. Her displacement is approximately 1000 tons. Her armament includes two 6in. howitzers, six 3in. 50-calibre quick-firing guns, four 75 mm. 12-calibre land guns, and eight rifle-calibre machine guns. The Parana, a view of which is given above, and her sister ship, the Rosario—also recently completed at the Elswick shipyard—besides having powerful armaments, are well protected for vessels of their class, and, in addition to other protection, they have an armour belt extending over the machinery spaces and magazines. It is believed that, combining as they do such good offensive and defensive qualities, the Parana and Rosario will be the most powerful vessels of their kind in existence. The main propelling machinery consists of two sets of inverted triple-expansion engines. The Parana is the fourth, and the Rosario the fifth, vessel the Elswick firm has constructed for the Argentine navy, the first being the 25 de Mayo, a cruiser of 3000 tons, completed in 1891, the second being the cruiser Nueve de Julio, of 3500 tons, completed in 1893, and the third the cruiser Buenos Ayres, of 4800 tons, completed in 1896. In addition to these vessels, the allied firm of Ansaldo, Armstrong and Co. have during recent years constructed the armoured cruisers Garibaldi and Pueyrredon, each having a displacement of about 6750 tons. The armament for all these vessels was supplied from Elswick, and in addition the firm has supplied the armament for other vessels of the Argentine navy, including the first-class cruisers General Belgrano and General San Martin. Both the Parana and the Rosario have been built from the designs of Mr. J. R. Perrett, of the Elswick shipyard, and, although primarily intended for river service, these gunboats should prove excellent sea-going vessels. The draught is small, and there is good manœuvring power. Special arrangements have been made to guard against the extreme heat to which these gunboats will sometimes be exposed on the great rivers of the Argentine, and ample provision has been made for keeping the ships cool throughout, and especially with a view to maintaining a comfortable temperature in the magazines and machinery spaces. In both vessels ample accommodation has been provided for the commander, officers, engineers, and crew, and there is in each vessel a complete electric lighting installation.

A NEW BAR-CUTTING MACHINE.

FOR cutting steel or iron bars up to 8¼in. in diameter, the firm of J. Butler and Co., of Victoria Ironworks, Halifax, has recently put upon the market the machine illustrated herewith. A machine of this type has been in use in the firm's own works for many years, and we hear that it has proved invaluable for cutting up bar iron or steel stock ready for the smithy or the lathe. The machine is said to be remarkably rapid in its action—far more rapid than a hand-saw, and much less expensive to work. Another special advantage claimed for it is that the ends of the metal are left square. The cutting is accomplished by a simple straight tool, which is made to revolve round the bar. The tool holder is of cast steel, and it moves in guides in the face of a large cast iron disc with a spur wheel on the outside which is driven by a pinion from gearing and fast and loose pulleys at the back of the machine. As will be gathered from the illustration, the disc is turned to fit a large bearing formed by the body of the machine, the upper half being secured to the lower portion by bolts. The bar to be cut is gripped in a strong vice close up to the tool slide, the other end being held in a supporting vice at the other side of the disc. The cutting tool is worked automatically towards the centre by an improved feeding device, which gives the feed at each revolution of the disc, and we are told that it does it so gradually that the cuttings are taken off in continuous coils. The body of the machine forms an oil reservoir, and a small pump supplies a constant stream of lubricant to the tool. A length gauge is provided near the supporting vice. Two cutting speeds are provided, the belt driving through two sets of gearing, so that by moving a lever in front of the machine the speed of the cut may be increased without stopping. The quick speed may thus be utilised as the tool approaches the centre of large bars.



BAR-CUTTING MACHINE

Round, square, or hexagon bars, we are informed, may be cut with equal facility, and angle irons may be cut up by providing cast iron mandrils, round which two pieces of angle iron are gripped in the vice. The makers call particular attention to the fact that a great advantage of the machine is that it is not essential that the bars dealt with should be absolutely straight.

AMERICAN ENGINEERING NEWS.

Dry dock for Hawaii. — The United States Navy Department will build its largest dry dock at the Pearl Harbour naval station in the Hawaiian Islands. It will have a sill at the middle for an intermediate caisson to divide it into two docks, 575ft. and 532ft. long, for vessels of ordinary length. The next largest navy dry docks are the Philadelphia dock, 800ft., and the one now being built in Puget Sound, 865ft. The Pearl Harbour dock will be 1152ft. long from the coping to the outer sill, 140ft. wide at the top, 35ft. deep from the mean high-water level to the sill. The walls and floor will be constructed entirely of concrete. Granite

lining will be used for the caisson seats, the coping at the entrance, and the inclined slides for delivering material to the bottom of the dock. The head of the dock is to be trapezoidal in plan, the arrangement being such that three torpedo boat destroyers may be berthed side by side at the head, leaving room for three other small craft between them and the intermediate caisson. The heel and bilge blocks will be seated on cast iron bearers or slides embedded flush with the floor, these being of hollow box form and forming drains which connect with four sub-floor longitudinal drains. Three lines of 54in. pipe, fitted with valves, conduct the water to a pump pit or suction well. The floor drains will be used also for filling the dock, the water rising vertically through the drain boxes. The inner or outer part of the dock can be drained or filled independently of the other when desired. Around the dock will be a line of rails for a 40-ton travelling crane, the inner rail being laid on the coping. The excavation will be made to a depth of nearly 60ft., the material being used for filling low ground. There will be about 120,000 cubic yards of concrete, composed of 1 cubic foot of Portland cement to 6½ cubic feet of broken stone and a varying proportion of sand.

Concrete arch railway bridge.—In widening its main line for four lines of rails, the Lake Shore and Michigan Southern Railway has recently pulled down a double line stone bridge with four 80ft. arches—built fifty years ago—and has erected in its place an armoured concrete arch bridge which is 70ft. wide over the copings. This bridge is designed for a live load of a continuous series of axle loads of 40 tons spaced 5ft. between centres. The main span is an arch of 160ft. clear span, with a radius of 84ft. and a rise of 71½ft. from the springing line. This is flanked at each end by an arch of 70ft. span having a radius of 37ft. The three arches carry transverse spandril arches surmounted by a horizontal concrete floor or deck 3½ft. thick. These spandril arches are of 10ft. span, and the walls which carry them are 3ft. thick. On each side is a low parapet wall, anchored to the floor by inclined steel bars embedded in the concrete of the floor and wall. The thickness of the arches at the crown is 7½ft. for the 160ft. arch and 4½ft. for the two side arches. All concrete was composed of 1 part Portland cement, 2 parts sand, and 4 parts stone. The only finish for the exposed surfaces was the spading of the concrete at the face of the form or mould, so as to work stones back from the face and leave a facing of fine mortar. The deck is covered with five layers of tarred felt laid in hot tar and carried up against the parapet walls. The steel reinforcement consists of square bars or rods, corrugated so as to give a mechanical bond with the concrete. These are of high carbon Bessemer steel, having an elastic limit of 27 tons per square inch.

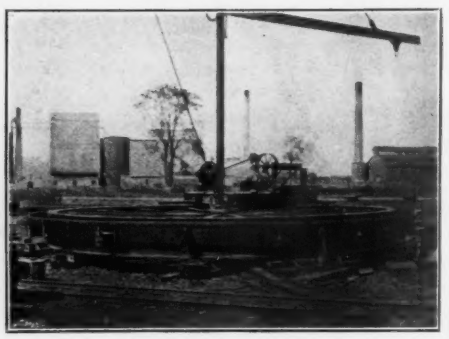
Developments in electrical engineering.—The annual report of the American General Electric Company contains some interesting notes of electrical engineering developments in 1908, due in part to the fact that slackness in business gave the company's engineers more time to consider improvements and economies. The sales of transformers of 60,000 volts in 1908 were nearly double those of 1907, and experience with high-tension transmission lines of 60,000 to 100,000 volts for long distances has been so satisfactory that pressures up to 150,000 volts are being considered for new projects. Switches have been put in commercial use which successfully control 110,000 volts, the highest voltage now in practical use. Two steam turbines of 14,000 kilowatts have been installed and found satisfactory, while designs have been made for a number of turbo-generators for operation by low pressure or exhaust steam. These range as high as 5000 kilowatts capacity. The economic value is based upon their higher efficiency than steam engines in the lower range of steam pressures between atmospheric pressure and a good vacuum. By utilising the exhaust steam of existing engines they are expected to increase the capacity of the combined unit by over 40 per cent., with a substantial reduction in coal consumption. An electric railway system for 1200 volts has been perfected and proved successful. The new vertical type of rotary converter has met with favour, being particularly valuable in the saving of space due to their compactness. A number of these have been built of 2500 kilowatts capacity. The great steel works of the Indiana Steel Company have started a rail mill, which is operated entirely by electric motors. The roll trains are directly connected to induction motors rated at 6000 horse-power, but having an ultimate capacity of 10,000 horse-power. The application of electric motors in this case effects considerable economies in the production of steel rails with increased output.

Portable air-compressor plant.—A large proportion of trench work in New York involves rock excavation, and in opening up trenches for the tubes of a postal transmission system a portable air-compressor plant was used to supply drills for the rock work. The drills included two ordinary tripod machines, and two pneumatic drilling hammers or hand drills. A heavy frame or wagon bed of rolled steel joists 17½ft. long is hung beneath two axles 12½ft. apart, with a tool-box and driver's seat just behind the front axle. A Fairbanks horizontal four-cycle single-acting petrol engine of 30 horse-power is mounted on the bed, and its shaft has a spur wheel driving another spur wheel on the shaft of an air compressor, whose cylinder is below and at one side of the engine cylinder. The engine has a cylinder 12in. by 18in., a centre crank, 5½ft. fly-wheel weighing 1650 lb. and runs at 190 revolutions. The compressor cylinder is 10in. by 10in., and makes 150 revolutions. At the rear end of the bed is a water tank 5ft. high, with vertical air tubes for cooling. It holds 200 gallons, and the water is circulated through the cylinder jacket by a rotary pump. Directly over the rear axle is a vertical air reservoir tank 2ft. diameter and 6ft. high, with 2½in. connections and automatic cut-off. Beside it is the vertical tank for petrol. There is a friction clutch in the driving gear between the engine and compressor. The plant has a maximum capacity of 134 cubic feet of free air per minute. It is hauled by a team of horses, and when in use blocking is wedged under the bed-plate to prevent vibration. The same plant might be used for riveting. For some riveting in the city of Chicago the contractors used small electrically driven compressors, the motor, compressor and reservoir being mounted on a wheeled truck hauled by a man. Flexible cord conductors were led to convenient connections.

Locomotive Boiler Construction in America.—Locomotive boiler construction in America has been two remarkable developments of late. The first of these is a fire-box without stay bolts. It consists of transverse diaphragm plates conforming to the shape of the space between the inner box and outer box—but pierced with numerous apertures for circulation, with channel-shaped plates whose webs form the sides of the fire-box and outer box, while their flanges are riveted to the diaphragm plates. This is the invention of Mr. Jacobs, assistant locomotive superintendent of the Atchison, Topeka, and Santa Fé Railway. It has already been applied to a 16-wheeled 10-coupled goods engine, and a number of the fire-boxes are being built at the railway company's works. By standardising the design, the punching and drilling of the diaphragms and the shaping of the channels has been reduced to an economical figure.

BRIDGE TURNTABLE PLANER.

AN electric planer for machining the turntable of a large bridge is shown in the accompanying illustration. As shown, it is at work at Decatur, Ill., in the establishment of the Decatur Bridge Company. The bridge for which this turntable was used has a span of 300ft. with a 20ft. roadway. The turntable was 20ft. in diameter, and a special electrically-operated tool had to be designed an constructed for planing it. The arrangement employed will be gathered from the illustration. A 10 horse-power electric motor of the four-pole direct-current type was utilised for driving the tool, and it will be noticed that the electric motor is belted to a counter-



BRIDGE TURNTABLE PLANER

shaft. This drives through bevel gearing a pinion engaging with the teeth on the periphery of the turntable, thereby causing the tool on the framework to travel and do its work. The speed used was 75ft. per minute on cast iron and about 40ft. per minute on steel. The engraving shows the planer actually in operation.

LEGAL INTELLIGENCE.

J. MUSGRAVE AND SONS, LIMITED, *v.* MAYOR, &C., OF BRADFORD.

IN this case, which was heard by Mr. Justice Darling—sitting without a jury, by consent—on June 17th, 18th, and 19th, an action was brought by the plaintiffs to recover £1200 0s. 10d., balance of the price of an engine and certain goods sold to the Bradford Corporaton. The defence was (*a*) that the engine was not capable of doing its work; and (*b*) that payment was only to be made on the certificate of the defendants' engineer, which had not been obtained. The defendants also counterclaimed £1996, being the cost of taking out the shaft of the engine and replacing it.

Mr. Walter, K.C., and Mr. Disturnal appeared for the plaintiffs; Sir Alfred Cripps, K C., and Mr. C. C. Hutchinson for the defendants.

The facts of the case, so far as material for the present report, were shortly these. The engine, known as the Elsie, was for supplying electricity to the Corporation tramways, and was the duplicate of an engine, the Maria, previously supplied. It was a compound engine, having a steel shaft some 23in. in diameter, and having upon the shaft a fly-wheel weighing some 70 tons and a "spider" carrying an armature weighing about 20 tons. The spider and fly-wheel had flanges, which were bolted together.

Payment of 85 per cent. of the contract price was to be made on delivery and erection. The remaining 15 per cent. was "to be paid at the expiration of twelve calendar months afterwards, provided always that the engine shall continue to work to the satisfaction of the engineer, and not otherwise, and his written certificate obtained to that effect." It was this 15 per cent. that formed the subject matter of the action. There were slight variations from the specification, the most important of which was that, instead of a crank shaft 18in. in diameter, the defendants supplied one 23in. in diameter. The trial run of the Elsie was admittedly satisfactory, but on August 11th two of the coupling bolts between the armature and the fly-wheel broke. According to the plaintiffs' case, this was due to a short circuit having occurred, a strain being thereby thrown on the engine Other bolts having broken, Mr. Blackman, the engineer, wrote in February, 1906: "I am not satisfied with the engine in its present condition, and I am of opinion that the repeated breaking of the coupling bolts points to the fact that the shaft is weak, and that this should therefore be replaced by your firm." The plaintiffs denied this, and pointed out that the shaft was identically the same dimensions as the shaft which was supplied in the Maria engine, which was running perfectly.

On the part of the plaintiffs, witnesses were called to prove that, in point of fact, the breaking of the bolts did not prove that the shaft was too weak—in fact, the breakages were due to the spider being slightly out of truth. Mr. Parshall gave evidence to the effect that the plant would have run perfectly well without any bolts at all. Eventually, however, the Corporation decided to take out the shaft and have a new one fitted. It was found that the fly-wheel was still quite true on the old shaft. By their counterclaim the Corporation claimed the cost of putting in a new shaft. It was contended by the Corporation that, so far as the claim was concerned, the certificate of the engineer was conclusive, and that the certificate of the engineer was a condition precedent.

In giving judgment, Mr. Justice Darling said: I come to the conclusion that Mr. Blackman really was not satisfied, that he thought the engine ought to have a bigger shaft, as the correspondence proves, and that he honestly was of that opinion; but I think he was unreasonable, because he came to that conclusion from the fact that these bolts broke. There is evidence that it is quite usual now to work such things as these without fixing the fly-wheel to the armature by means of bolts, and I have no evidence that when these bolts did break anything happened to the engine, except that the bolts did break. After discussing the causes which might have influenced the engineer in refusing to certify, his lordship concluded that he refused to certify from an honest conviction that the shaft was not strong enough, and therefore the plaintiffs' claim failed.

The case for the plaintiffs on the counterclaim was that the fly-wheel as supplied was absolutely accurate. The breaking of the bolts had nothing to do with the shaft. That was caused, as he would show, by the spider being untrue to the extent of 4000ths of an inch on the side from the keyway. In these circumstances the plaintiffs contended that they ought not to be saddled with the cost of putting in a new shaft and one which was larger than they originally intended.

Mr. Justice Darling, in giving judgment on the counterclaim, said the onus was on the defendants to prove that the shaft was unsatisfactory. They had said that the shaft was not of the proper quality, that it was not properly manufactured in that it was made of steel, which could have been made into a proper shaft, yet from over-annealing of the shaft it was not fit for the work which it was put to do. They also alleged that if the damage did not arise in this way it did arise because the flanges and the armature were not true, so that when they were fastened together by the bolts the bolts kept snapping, and that this was a matter for which the plaintiffs were liable. He held that it was not proved that the shaft was defective. The condition of the shaft had nothing, in his view, to do with the breaking of the bolts. He was of opinion, however, on the evidence, that the non-fitting of the two flanges had an appreciable effect; and that given sufficient time—it was impossible to say how much time—that defect alone would have torn the bolts asunder. The plaintiffs were therefore liable in damages.

At this point Sir Alfred Cripps intervened to say that the damages were agreed at £10.

Judgment was entered for defendants on the claim and on the counterclaim for £10. Defendants to have the general costs of the action; but the plaintiffs to have the cost of the issue on which they succeeded, namely, the question whether the shaft was of the proper strength or not.

LETTERS TO THE EDITOR.

(*We do not hold ourselves responsible for the opinions of our correspondents.*)

THE INSTITUTION OF CIVIL ENGINEERS.

SIR,—In your issue of the 30th of April last is a leader on "The Institution of Civil Engineers," in which, after referring to the report of the Council of the Institution presented at the annual meeting on the 27th April, you express the opinion that the proposals of the Council "are a long way from being what many members would wish to see." Again, in your issue of the 7th May, page 466, you refer to 'an agitation that has been carried on amongst a considerable number of members of the Institution." You say "there is a widely spread feeling of dissatisfaction regarding the manner in which the affairs of the Institution are managed," and you assert that "the majority of members are dissatisfied," and add that you do not "think it well that the matter should be dropped where it now is."

The influence of the Institution, for good or evil, on the engineering profession is so great that it is not only reasonable, but, it seems to me, imperative, that every member thereof should give attention to statements such as these when made in a journal of the standing of THE ENGINEER, should endeavour without prejudice to examine all that is urged against the management of the Institution, and should be prepared to reform the management if it is shown either that it is not doing all it might do, or that some change in the constitution of the governing body would improve it. Thinking thus, I have read with attention all that has, to my knowledge, been brought up against the management of the Institution, and I must confess I have come to the conclusion that there is little, if any, real cause for dissatisfaction, and that such changes—or "reforms," if you please to call them so—as time renders necessary, are being made by the Council quite as quickly as seems to me desirable.

So far as THE ENGINEER is concerned, I have no recollection of any definite charges being made against the management of the Institution, nor, so far as I know, has it made any definite proposals of "reform." But those you call the "reformers," as by this term I understand you to refer to the gentlemen who held a meeting in Caxton Hall, Westminster, in June last, and elected a committee to propagate "reform," have issued a set of "questions on reform," and have submitted those questions to the members of the Institution. The questions are six in number, and the committee who framed them evidently consider that they refer to the most important matters needing reform, as in paragraph 7 of the letter accompanying the questions it refers to "many minor questions of reform" not touched by the questions therein asked. With your permission I would discuss these questions in some detail.

The points raised by them are:—

(1) The re-organisation of the governing body of the Institution.

(2) The framing of regulations for the guidance of corporate members in respect of professional practice and conduct, and of a scale of minimum pecuniary remuneration.

(3) The Institution entering more prominently into research work.

(4) The more effective working of the present system of assisting corporate members and students to obtain appointments.

(5) The modification of the present system of examinations whereby greater prominence may be given to practical experience.

(6) The promotion of the general utility of the Institution premises, and of its publications.

Leaving the first question to be dealt with last, I would, in the first place, point out that the matters referred to in questions 2 and 5 are the most important points raised, and they are and have been for some time receiving very careful consideration at the hands of the Council, which has submitted its recommendations upon them, which recommendations I gather, from the remarks in your leader of the 30th April, the "reformers" did not see fit to discuss. I have not the least doubt that the Council would have welcomed any criticism of its proposals, and would have been glad to take advantage of any workable suggestion that the "reformers" might have made.

That no criticism was offered leads one to the conclusion that the proposals of the Council are acceptable to the "reformers," or that, if not acceptable, they at least are unable to improve them.

In the second place, I would ask whether it is really contended that the matters referred to in questions 3, 4, and 6 are of such supreme importance as to demand or warrant special meetings of "reformers" and specially appointed committees to deal with them? To me they seem very ordinary matters indeed, matters that could be amicably and easily settled under the ordinary by-laws of the Institution, and that would, if so brought forward, receive the careful and sympathetic consideration of the Council.

I now return to the first question, the advisability of re-organising the constitution of the Council.

I think a question of this kind is always to be regretted, and that it should never be raised except for very cogent reasons. The "reformers" have shown absolutely no reason. The question is, if I may say so, flung at one's head without an apology, and without any attempt at justification. For myself I do not favour change in the constitution of the governing bodies of institutions merely because some irresponsible members think that they, or some of their friends, could run things better. My experience teaches me that a change in the *personnel* of a governing body has little, if any, effect on the management, and that it is a fallacy to suppose that, as a general thing, the election of A. in place of B. will improve matters. But in the present instance I do not see that in this direction any improvement is necessary. The Council of the Institution appears to do its duty excellently. The work done by the Institution in the past, and its present high position, seem to me to be ample confirmation of this, and I see no grounds

whatever for agitating against the management or for altering the constitution of the Council.

Lastly, will you allow me, as a member of the Institution, to express my disapproval at the way the "reformers" have set about "reforming." They have, so far as I know, made no attempt to bring forward their "reforms" in the ordinary way provided for by the by-laws, and they do not appear to have ever put them before the Council.

Without taking action under the constitution of the Institution, they have called an unauthorised meeting of members, have formed a committee to frame "questions on reform," and have started an agitation against the Council. To my mind such action could only be justified as a last resource, and it should never have been entered upon until every constitutional means had been tried and failed.

J. FORREST BRUNTON,
Karachi, June 1st. M. Inst. C.E., M.I. Mech. E.

MARINE PROPULSION.

SIR,—The number of correspondents writing on this subject shows such signs of increasing that, in all probability, unless some method be adopted, the discussion will prove abortive. I have in mind a discussion on this same subject in your columns about four years ago, in which some eighteen correspondents took part; my impression is that most of them discussed different points, but the result of the discussion was that no one correspondent succeeded in convincing any other correspondent on any point whatever, and that you, Sir, put a stop to it, no doubt to the great relief of your readers.

In order to avoid a similar result if possible, and in the absence of a better arrangement, I propose, for my own part, with your leave, to discuss the matter with Mr. Preidel without entering into side discussions with other correspondents. After Mr. Preidel and I have finished I shall be glad to discuss the question with your correspondent "X.," to whose last letter I shall not forget to reply; and after that to reply to "A. R."

Replying to Mr. Preidel's letter of June 5th, I am very glad we understand rightly what is each other's contention. Mr. Preidel writes a long letter, but a good deal of it is not about the point under discussion. In so far as he is discussing marine propulsion with me, Mr. Preidel must demonstrate the principle that work of action is necessarily equal to work of reaction before the discussion can proceed. Mr. Preidel approves of my review of the discussion, in which I show that the principle stated is the point on which our theories part company. I proved in my letter of April 27th that this principle is incorrect; Mr. Preidel replied questioning a certain part of my proof; I then explained and demonstrated that part of my proof very fully; but his reply deals mainly with other matters.

If I could only procure Aveling's "Natural Philosophy," from which Mr. Preidel quoted, perhaps the air would be cleared; but my booksellers report that the publishers (Kegan Paul) say that it is out of print. They are advertising for a second-hand copy, but it is doubtful whether this will find one. No bookseller in this town has it, and it is in none of the libraries. I greatly wish to obtain it or borrow it; can Mr. Preidel or anyone suggest how this is to be done?

As regards the statement in my letter of April 27th to which Mr. Preidel objected, viz., "the kinetic energy in foot-pounds supplied to the gun and bullet respectively, or the work in foot-pounds done on each—which all the text-books prove is the same thing—is

$$\frac{M V^2}{2g} \text{ and } \frac{m v^2}{2g},$$

this statement was part of my reply to Mr. Preidel's quotation from Aveling's "Natural Philosophy," viz., "when a bullet quits a gun, the gun 'kicks,' that is, as the bullet flies forward in one direction, the gun flies back in the opposite direction; and it is found that the amount of 'work' done by the bullet and the gun are equal and opposite." This is Mr. Preidel's own quotation. It is obvious that Dr. Aveling is here neglecting friction and energy spent on sound waves and all such considerations met with in practice. He is quite obviously speaking in a theoretical sense only; therefore when I prove in my letter of April 27th that Dr. Aveling is wrong, I, of course, proceed on the same theoretical lines on which his statement is made; to do otherwise would be to quibble. Then Mr. Preidel wrote objecting to my statement as quoted above; and in my letter of May 29th I explained and demonstrated it very fully, always proceeding on the same theoretical lines on which the matter was broached by Mr. Preidel himself. Mr. Preidel, in reply, writes a long dissertation on guns, in which these theoretical lines are thrown to the winds, and he comes to the conclusion—the obvious conclusion on the lines he now adopts—that the total work done by the explosion exceeds the combined kinetic energy supplied to the bullet and gun. May I point out that, on whatever lines we proceed, this conclusion has nothing to do with the case, for my statement does not say that the total work done by the explosion is equal to the kinetic energy of bullet and gun, but that that part of the work of explosion which is done *on the bullet and gun* is equal to the kinetic energy supplied to each respectively. My statement still remains correct, and the only result of Mr. Preidel's dissertation is to destroy what semblance of truth there was in his own quotation; for while Dr. Aveling mentions only the work done on the bullet as being equal to the work done on the gun, Mr. Preidel shows that there is also the work done on the atmosphere to be taken into account and set against the work done on the gun.

As regards the definition of "measure of work," it appears that Mr. Preidel has now dropped his theory that work done is correctly represented by momentum, or work = mass × velocity, and that he adopts the definition of measure of work as being the product of mass moved and the distance through which the mass moves while it is being acted upon by the force. May I explain to him that his definition is only correct in the case of masses moved vertically upwards against the force of gravity alone, and, seeing that in all the cases that have come into the discussion the masses are moved more or less horizontally, his definition will not apply at all. For example, if a bullet of a mass of $\frac{1}{4}$ lb. be acted upon by a force of 1000 lb. through a distance of 3ft., the work done on the bullet will not be $\frac{1}{4} \times 3 = \frac{3}{4}$ foot-pounds according to Mr. Preidel's definition, but it will be $1000 \times 3 = 3000$ foot-pounds.

I gave my definition of "work," or rather "measure of work," in the first paragraph of my letter of April 27th, viz.:—"If a body moves through a certain space against the action of some force, work is done equal to the product of the force and the distance through which the body moves." Will Mr. Preidel kindly say whether he will accept this definition?

May I again remind Mr. Preidel that I first entered on this discussion by pointing out to the initiator of it his mistake in assuming that the work of action is necessarily equal to the work of reaction; that Mr. Preidel then wrote affirming that the work of action and reaction are equal; that my reply to this—dated April 27th—demonstrated the truth of what I had previously said; and that in so far as he is discussing the matter with me, it still remains for him to show in some rational way that that reply is not correct. If he fails to do this, he fails to show that his theory of marine propulsion is not based on a fallacy. I, of course, still maintain that the whole of the matter in that letter is correct, and that up to now Mr. Preidel has said nothing which can be interpreted as showing that any part of it is wrong.

June 19th. T. S. C.

LATENT AND SENSIBLE HEAT.

SIR,—Whether Mr. Aspinall is right or wrong in his views, it is clear that he deserves thanks for courageously trying to deal with steam from the physical instead of the mathematical point of view. Steam is steam. It is a vapour, and not a gas. It is of the last importance that we should keep it intact, whole, and sound. In other words, prevent its return to the condition of water. Ostensibly steam can be turned into water either by abstracting heat directly as heat, or by making the steam do work.

No phenomenon of the latter kind is met with when we use a gas to do work, as, for example, a hot-air engine. The loss of heat causes a reduction in volume, but this is quite insignificant as compared with the loss which takes place when steam is re-converted into water. It has been too much the habit to treat steam as a gas. Some of it is liquefied in a cylinder, but what is left is regarded as a gas, with which it has nothing in common, save that both are elastic fluids.

When we speak of loss of heat, we as a rule use the words quite vaguely, and seem to regard the nature of the physical change in precisely the same way whether liquefaction is the result of the performance of work or of loss of temperature. This assumption is, I think, unfounded. We say that so much steam heat is converted into work, and that the result is numerically the same as though the steam were cooled with water.

Now, curiously enough, there is no evidence whatever derived from experiment or practice to prove that this is the case. On the contrary, it is absolutely impossible to substantiate the theory by the aid of any practicable form of steam engine. If it were otherwise, there would be no dispute about "the missing quantity." In other words, we do not know how much steam may be condensed by the direct abstraction of heat. We do not know how much will be condensed in the performance of work, and this I say with a full knowledge of Donkin's investigations and the usual systems of making a heat balance. There is always a great deal more steam liquefied than can be explained by the performance of work, and the position is such that, if I said that twice as much steam had to be liquefied to produce a thousand horse-power as calculation declares to be needed, no one could prove by actual practice that I was wrong. If Mr. Aspinall can help us to clearer views on this point he will have accomplished much.

Leaving generalities, permit me to ask a few suggestive questions concerning steam and its life, death, habits, and customs.

What do the words "loss of heat" mean? Is it always accompanied by a fall in temperature? I do not think it is. If we take a pound of true steam with a pressure of 100 lb. absolute, we find that the total heat in it is 1181.4 deg. Fah. We expand it down to 10 lb.; the total heat in 1 lb. of steam at this pressure is 1140 deg. The difference is 41.4 deg. representing 31,126 foot-pounds. It appears, then, that this represents heat which may be converted into work without producing condensation or change of state in the steam.

At the outset the temperature of our pound of steam was 327·9 deg. After expansion it is 193.3 deg., a difference of 134.6 deg., and the latent heat has risen from 882.6 deg. to 978.4 deg., a difference of 95.8 deg. Now what does this imply? Does this shifting of temperatures mean the performance of work? and if so on what or in what way?

The fall in temperature is not due to the performance of work at all. It is due to the fall in pressure. It is an immutable law that the temperature of steam shall be determined by its pressure and volume. If steam is condensed directly it loses temperature; but there is no reason to believe that steam is cooled by doing work. Indeed, we are told definitely that the conversion takes place directly in some way not understood; and that nothing could go on in a non-conducting cylinder to affect temperature but change of volume. It appears, therefore, that the sensible heat of steam takes no part in the conflict. All the work is done by the latent heat. What does this imply?

The first thing that strikes us is that the less the latent heat the greater the work that a pound of steam can perform. Is not this contradictory? Is sensible heat first converted into latent heat, and does this, then, do the work? No one knows. I ask in vain.

Again, study what takes place when steam is compressed. Mr. Aspinall has something to say on this point. A remarkable experiment made by Mr. Yarrow shows that a bubble of steam in boiling-hot water contained in a vertical tube about 4ft. long can be made to appear and disappear by shifting it from the bottom of the tube to the top, and *vice versâ*. In the steam engine, if there is in the cylinder water of the same temperature as the steam to the extent of 30 per cent. by weight, compression beyond a certain degree will only produce liquefaction. The rising compression curve on an indicator card is suddenly converted into a horizontal line. It would seem that the steam is absorbed by the water, as though it were CO_2.

Rankine, writing of clearance, said that the injurious effects of clearance might be completely neutralised by raising the compression pressure to that of the boiler before the steam port opened. This looks all right on paper; in practice it is all wrong. Why?

Lastly, let me say with what pleasure I have read the admirable article, "Thermodynamics in Theory and Practice," which appeared on page 600 of your impression for June 11th. I conclude this discursive epistle with a quotation from it: "The science of thermodynamics is a glaring example of the unreliability and uncertainty of the practical application where the theory is incomplete."

June 20th. G. B. D.

LIFE OF THE LOCOMOTIVE.

SIR,—Mr. Price Williams has compiled so many interesting statistics in his paper forming the subject of the leading article in THE ENGINEER of 18th June, that it is unfortunate that in one of his leading data he has been misled by accepting the Board of Trade Returns as his source of information. The number of locomotives shown in the returns as owned by each company is the divisor used in each case to arrive at the cost of repairs and renewals per engine, which would of course be correct if all the returns were prepared on the same basis. But this is not the case. Some companies include duplicate stock in the returns; others do not. For example:—In 1905 the London and North-Western Railway owned 2560 "ordinary stock" and 475 "duplicate" engines, making together the 3035 returned. The Midland Railway owned 2790 ordinary and 136 duplicate—in all 2926; whereas the return only gives 2790. Now it is clear that to compare the cost of repairs and renewals per engine of these two railways either the divisor for the London and North-Western Railway should be 2560, or that for the Midland Railway 2926. Duplicates should either be included or omitted in every case.

Other lines are affected in the same way, and, in fact, the grand total of 19,047 in 1905 would be very much larger if all duplicate stock were included; and the £232.85 cost per engine would be considerably reduced. The writer thinks duplicates ought to be taken into account, as money is spent upon them so long as they are in service; and, therefore, the number of duplicate engines possessed by each railway company in each of the years under consideration should be ascertained by application to the companies, and the whole of the figures revised.

On one other point the writer joins issue with Mr. Price Williams. There is always some difficulty in expressing what is meant by "depreciation." Mr. Price Williams appears to limit the meaning of the word in this case to the loss of value due to wear and tear, which can be—and is, during the life of a locomotive or any other machine—made good from time to time by repair and renewal. But there must be a further loss of capital value in any machine owing to its effluxion of life; in other words, in any statement of assets, an engine or machine must be valued according to the "serviceable life period"—to adopt Mr. Price Williams' very clear definition—remaining in it, assuming that it is maintained in the maximum state of efficiency and repair; and this is "depreciation" just as much as loss of value due to the deterioration which would occur if repairs and renewals were neglected.

With reference to Mr. Price Williams' figure of £2500 as the value of an engine, does he not apply it to the engines of 1869? He is dealing with the figures of that year, which, he says, would have provided 138 modern engines at £2500—meaning, apparently, modern at that period. The price in 1869 would have been about the sum named.

London, June 22nd. JAS. ED. DARBISHIRE.

AUSTRALIAN PUBLIC WORKS.

SIR,—Might I ask for a little space in reply to Mr. C. O. Burge's letter in your issue of 11th June? In the original article—28th May—the keynote I took to be the remark, "It is the people only that make a country and require laws, buildings, &c."

Now I would commend to the careful attention of Mr. Burge the figures below, which I quote from Bulletin No. 1, page 15, Commonwealth Bureau of Census and Statistics.

Annual Increase Per Cent. Australia over Periods

1851-1861	11.07
1861-1871	3.76
1871-1881	3.05
1881-1891	3.52
1891-1901	1.71

In other words, the population of the Commonwealth is increasing, but the rate of increase shows a very marked tendency to decrease. Hence many who have studied the matter fear that the population has reached, or very soon may reach, a point of no motion.

Mr. Burge will now be in a better position to understand the true inwardness of Lord Northcote's speech—*Standard*, 28th May—on the Colonies. On that occasion Australasia was actually spoken of as "waiting a vigorous and thriving population." While I gather, too, that the Commonwealth was meant to be included, when the speaker went on to forecast that "for many years to come the sparse population must rely upon the Mother Country for aid and protection."

Whatever the results of the public works policy have been the settling on the land—exclusive of the cities—of a vigorous and permanent race is still a problem to be solved. Victoria has, I understand, taken the lead in retrenchment. There is much scope for others to follow the example.

STATIST.

INSTITUTION OF MINING ELECTRICAL ENGINEERS.—A meeting of the above Institution will be held in the Lecture Theatre, North of England Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne, on Saturday, June 26th, at 7 p.m., for nominating officers for that branch for representation on the General Committee, and report of progress of Institution to date.

A NEW STEEL FLOATING DOCK.—On June 15th the largest steel floating dock of Norway, built by the A/S Framnæs mek. Værksted, Sandefjord, for the Nylands Værksted, Kristiania, was successfully tried at the builder's yard in Sandefjord. The principal dimensions are:—Overall length over pontoons, 319ft. 8⅜in.; width over pontoons, 86ft. 0⅝in.; height of side walls and pontoons, 33ft. 9⅝in.; clear width, 61ft.; maximum draught of vessel to be docked, 18ft.; height of keel blocks, 4ft.; lifting power, maximum, 4500 tons; time of lift, 3500 tons, two hours. The floating dock, which was designed by Messrs. Clark and Standfield, Victoria-street, Westminster, London, is of the self-docking, bolted sectional type. It is divided into three sections by joint chambers, the middle section being rectangular in plan, and the two end sections having their outer extremities built in the form of a point or bow.

DREDGERS FOR SINGAPORE, SUDAN, AND NIGERIA.—In connection with the carrying out of the large port improvement contract which Sir John Jackson, Limited, have in progress at Singapore, Wm. Simons and Co., Limited, Renfrew, launched for that firm on June 1st, with steam up, complete and ready for work, a bow-well barge-loading bucket-ladder dredger, named Hydra No. 6. The dredger is fitted with a set of triple-expansion surface-condensing engines and a mild steel multitubular boiler constructed for a working pressure of 160 lb. per square inch. The engines are arranged either to drive the propeller or the dredging gearing, as may be required. In consequence of the successful working of the twin-screw suction hopper dredger Egerton which Simons and Co. built about two years ago for the Government of Southern Nigeria, an order was some time ago given to the firm by the Crown Agents for the Colonies, on account of the same Government, for a similar dredger, but of larger dimensions and much larger carrying capacity, and the new vessel was launched on June 8th. This vessel, named the Sand Grouse, although larger, is fitted with practically the same pumping outfit as the Egerton. The suction pump is driven from a set of triple-expansion surface-condensing engines, and is capable of dredging sand at the rate of 2500 tons per hour from a depth of 35ft. below water level. For preventing damage when the dredger is working on an exposed bar, the lower end of the suction pipe is so arranged that the vessel can plunge about without disturbing the nozzle on the ground. The dredger will be propelled at 10 knots speed by two sets of triple-expansion engines. Steam is supplied from three steel boilers of the Scotch type, constructed for a working pressure of 180 lb. per square inch. Messrs. Simons and Co. have just finished an order recently received from the Irrigation Department of the Sudan Government for a specially designed dredging vessel, which will be principally employed dredging the sudd in the White Nile. Owing to the limited depth of water which prevails at some of the places where dredging operations are to be carried out, the dredger will be of very shallow draught, and will be propelled by a paddle wheel at the stern.

INSTITUTE OF MARINE ENGINEERS.—On Saturday, June 19th, the members of the Institute of Marine Engineers paid a visit to Trinity House, Tower Hill. The building was erected in the year 1794; the constitution of Trinity House, however, dates from the year 1514, in which year a charter was granted by Henry VIII. giving considerable powers, including maritime legislation, shipbuilding, the provision of storehouses for arms, ammunition, &c., but in later years its work has been chiefly confined to the control of pilotage and the upkeep of lighthouses, lightships, buoys, &c. Some time ago it was made a department of the Board of Trade, but it occupies the somewhat anomalous position of being at once a Government department while retaining the privileges of a private corporation. The present Master of Trinity, a position generally occupied by a prince of the Royal Family, is H.R.H. the Prince of Wales. There are twenty-four Elder Brethren, eleven of whom are honorary and thirteen acting members, and an unlimited number of Younger Brethren. The acting Elder Brethren must be officers who have attained the rank of commander and have had command of a ship of war at sea for at least three years if in the Royal Navy, or must have served in command at sea on foreign service for four years if in the mercantile marine. No special qualification is necessary for the Younger Brethren, a position entirely honorary and involving no duties, but in practice only persons connected with the Royal Navy or the merchant service are ever chosen. The subjects which excited the greatest amount of interest among the visitors were the very fine models of lighthouses and lightships, including models of the Eddystone, Smalls, Wolf Rock, Needles, Maplin, and other well-known lighthouses; also a model of the Roman "pharos" in the grounds of Dover Castle, one of the earliest lighthouses known. The collection of buoys in the entrance hall includes many types of buoys now obsolete, and other elaborate buoys used at the present time—bell buoys, arranged so that a bell is sounded in rough weather; whistling buoys, the up-and-down motion of the waves providing an automatic blast for the whistle; others with devices by which a light is shown from the head of the buoy, and other ingenious attachments and designs. In this room also is a model of the most recent light-buoy, which is loaded with oil, and performs its duties unattended for a period of six months at a time.

MACHINE FOR DRILLING RAILS AND DRIVING SCREW SPIKES

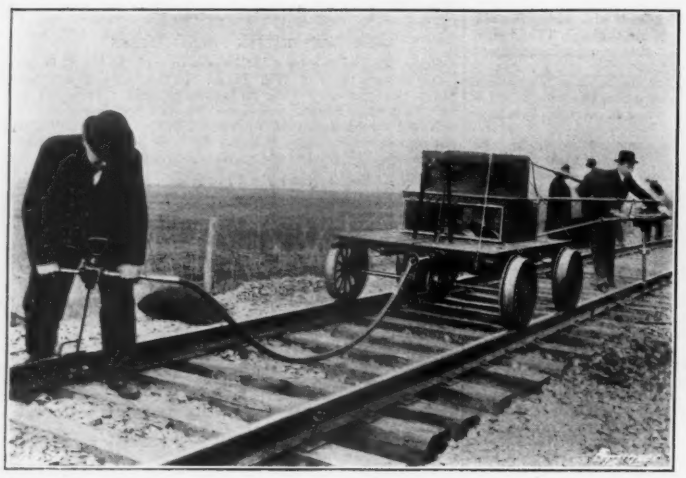


Fig. 1

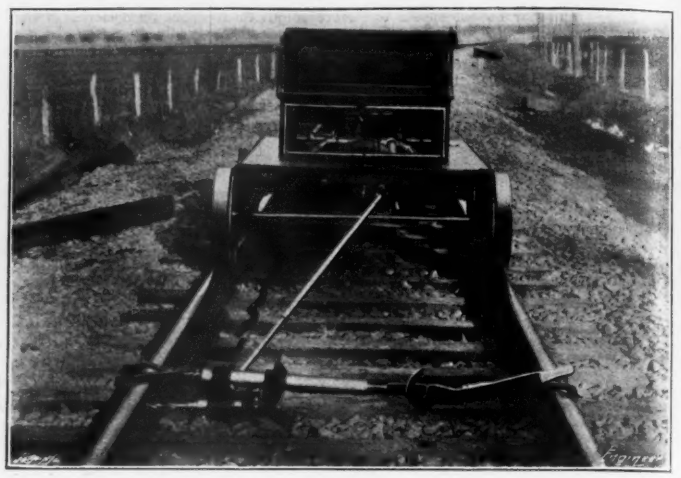


Fig. 2

MACHINE FOR DRILLING RAILS AND DRIVING SCREW SPIKES.

THE use of screw spikes in permanent way construction has made but slow progress on American railways, and one of the objections to their use is the labour of boring the sleepers and screwing home the spikes. A hand power machine has been devised, having a vertical shaft with a socket, which is revolved by bevel gears by means of two crank handles. This is a somewhat awkward arrangement for any extensive use. In laying tramway permanent way in Chicago, the augers and spike drivers were electrically-driven machines, current being taken by means of a rod hooked over the trolley wire.

The Atchison, Topeka and Santa Fé Railway is, however, making some extended trial of screw spikes, and is using a special machine to supply power for the augers and drivers. The idea is based on the petrol-operated lorries now employed by many progressive railways for the use of the maintenance gangs, thus saving the energy expended by the men in driving a hand-operated lorry when going to and from work. The machine is a four-wheeled platform truck, or lorry, which may be lifted on and off the rails by the men. On it is a petrol engine, and power is transmitted to the tools in either of two ways. In one arrangement, a shaft extends longitudinally under the platform, and has a coupling at each end for a flexible shaft, the free end of which is attached to the tool-driving mechanism held by the workman. In the other arrangement, the engine drives an air-compressor, and a length of hose is led to the tool carrying the auger or driving socket.

In Fig. 1 the machine is shown with both devices in use. The man at the left holds the auger, and it will be seen that an iron strap is set upon the rail, this carries two hollow studs in which the auger is placed, thus automatically getting the proper position and inclination. Steel base-plates are used on each sleeper. The man at the right is holding the tool which carries the socket wrench for screwing in the spikes.

In Fig. 2, the machine is operating a rail drill, which is held by the adjustable bars clamped across the rails. The machine may be used also for various purposes: it can operate rail saws, pneumatic riveting tools, paint spraying apparatus, &c. It has been found that with this machine one man with the auger can bore nine holes while two men with a crank auger are boring one hole. In the same way, one man with the power-operated socket wrench can screw in five spikes while two men with a cross-handled socket wrench are screwing one spike. In regular service the machine has one auger in front and two spike drivers behind, so that the two processes make about the same rate of progress.

The motive power is a 12 horse power petrol engine, which also propels the trolley by means of a sprocket chain drive to one of the axles. The inventor is Mr. H. W. Jacobs, assistant locomotive superintendent of the Atchison, Topeka and Santa Fé Railway at Topeka.

As a result of the terrible mine explosion at Courrières in 1906, the Central Committee of the Coal Mines of France has erected a testing station at Lievin, where all questions regarding the safety of mines can be studied.

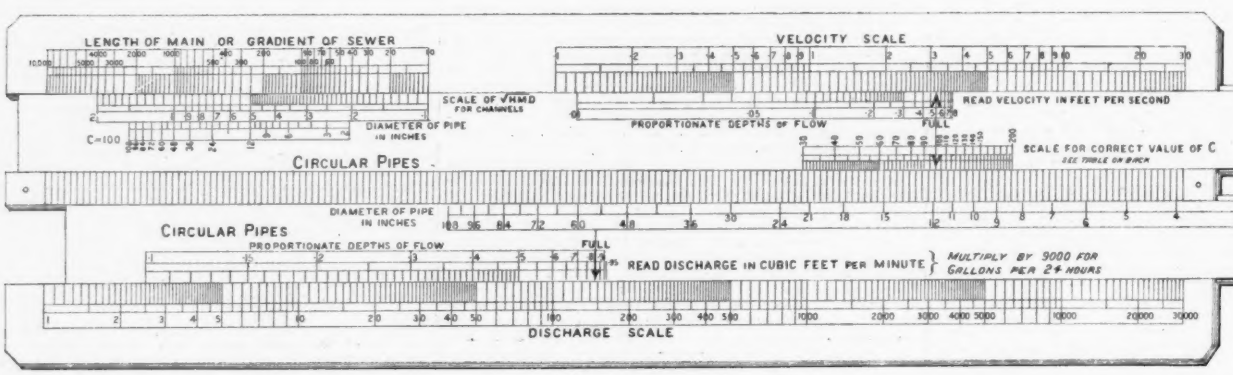
A NEW CALCULATOR.

MANY aids for calculating the rates of velocity and discharge from pipes have been put at the disposal of the engineer at various times, but they have been applicable to one formula only. Realising the need for some simple calculator which can be conveniently handled and carried about, and which is readily adjustable to any or all of the different formulæ in common use, Mr. E. H. Essex, Assoc. M. Inst. C.E., has designed the special calculating rule shown in the accompanying illustration, and it is being put upon the market by W. F. Stanley and Co., Limited, of Great Turnstile, Holborn, W.C. It is intended principally to enable the engineer to ascertain rapidly, and with some fair degree of accuracy, the rates of velocity and discharge from sewers and water mains. Incidentally it can be used to find the velocity of discharge in different forms of channel, and, by the introduction of another set of slides, to obtain the discharges from gas mains, compressed air mains, or steam mains.

The makers, in placing this new calculator on the market, call attention to the fact that the engineer has not only to decide which formula to use for the different classes of material and circumstances under his consideration, but he may be frequently called upon to compare his results with those obtained by others using different formulæ. This can readily be done by means of the additional scale for the current value of C upon the upper slide, representing the variable coefficient in Chezy's original formula $V = C\sqrt{Rs}$ upon which all the later formulæ are based.

To find the velocity and discharge of a circular pipe laid to any gradient, say a 12in. pipe with a fall of 1 in 250, the upper slide is moved until the diameter of the pipe, or its equivalent, $\sqrt{H.M.D.}$, and the required gradient come opposite each other on the two scales at the top left-hand side of the calculator, as shown in the illustration. The velocity is then read opposite the arrow on the right of the top slide. In this instance it is 3.18ft. per second, as can be seen from a close inspection of the illustration. To obtain the discharge, the lower slide is moved till the diameter comes opposite the arrow on the upper slide, as shown. The discharge is then read opposite the arrow on the lower slide. It will be seen that in the illustration the diameter, *i.e.*, 12, is a little too much to the left, but if it were directly opposite the arrow, the discharge given under the arrow on the lower scale would be 149 cubic feet per minute. As the lower slide stands in the illustration the discharge is given as about 146. For corrections for the formula $V = C\sqrt{Rs}$, the method of procedure is as follows:—Taking Kutter's formula $n = .013$, from a table at the back of the calculator, it is found that C for this value of n is 85. Having found this value, the lower slide is moved until the diameter is opposite 85, on the scale for the correct value of C, on the upper slide, instead of opposite the arrow. The discharge is then read as before, which, in this particular instance, if the slide were shifted, would be 127. To obtain the corrected velocity, the upper slide is moved until the arrow is again opposite the diameter on the lower slide, and the velocity is read as before. In this particular instance, if the slide were moved as described, it would be found to be 2.7. Having found the velocity and discharge when flowing full, it is not necessary to make any further movement of the slides to obtain the velocities and discharges at any other depths of flow, for these may be read off directly by means of the scales marked proportionate depths of flow on the top and bottom slides. The velocities and discharges of standard Ovoid culverts are found in a precisely similar manner by merely reversing the slides.

A smaller calculator is also made, which is rather more convenient to carry about than the one illustrated, but it is necessarily limited to Kutter's formula, with value $n = .013$ for sewers and culverts, and an alternative value of $n = .011$ for water mains.



SLIDE RULE FOR CALCULATING RATES OF VELOCITY AND DISCHARGE FROM PIPES

A NEW PROCESS OF TREATING STEEL.

PEARLITE is the trade name applied to steels treated by a special process at the works of the Pearlite Steel Company, Beeley Wood, Sheffield. The process consists in first heating the steel in bar or rod form to a uniform red heat and then dipping it into a bath containing a solution of a certain ingredient, the nature of which is a secret. It is claimed, however, that the constituents of the bath are such as will generate hydrogen gas when brought in contact with the heated metal, and that the gas permeates the metal, driving off oxygen and nitrogen, and giving it a homogeneous and uniform structure throughout. We are unable either to verify or dispute the chemical action. We have submitted samples of steel bars 2in. square by 8in. long with the following analysis to the Pearlite treatment:—

	Before Treatment. Per cent.	*After Treatment.* Per cent.
Specimen 1.—		
Carbon	0.28	0.30
Manganese	0.64	0.63
Specimen 2.—		
Carbon	0.41	0.42
Manganese	0.62	0.63

The pieces were forged down to 1¼in. square and tested with the following results:—

	Before Treatment. Per cent.	*After Treatment.* Per cent.
Specimen 1.—		
Yield	23.0	27.0
Break	34·5	75.7
Elongation	33.0	33.5
Specimen 2.—		
Yield	27.0	27.0
Break	39.9	41.0
Elongation	30.0	28.5

Chisels made from the specimens not tempered but merely hardened in water were found to be equal in cutting quality to the ordinary chisel steel tested against them, and the treatment seems to have a beneficial effect for this class of tool, for comparatively low carbon steel can be utilised, and as the tools do not require to be tempered the makers claim that they can be placed in the hands of smiths with no special knowledge of the handling of this class of tool.

THE OPERATION AND MANAGEMENT OF THE PARSONS MARINE STEAM TURBINE AS PRACTISED ON THE U.S. S. CHESTER.

By Lieutenant A. F. H. YATES, U.S.N , Member.*

THE writer's experience with turbine engineering has extended over a period of little more than four months in the shops and slightly more than one year at sea. It has been confined mainly to experience with the turbines of the U.S. S. Chester. In view of these facts, I can hardly presume to discuss in all completeness such a broad subject as the head lines cover. At the time I began my experience with the turbine, however, I searched in vain for literature of this nature and can safely say that none exists. I trust that my remarks will prove interesting and of value, particularly to those who for the first time become associated with the practical operation of the turbine, and if such be the case I shall feel amply rewarded, as my efforts are directed primarily to that end.

The turbine installation on the Chester is of the standard type designed by the Parsons Marine Steam Turbine Company and differs to no marked degree from the latest systems now under construction. A brief description should suffice.

There are six ahead turbines, a high-pressure cruising, intermediate-pressure cruising, two main high pressures, and two low pressures. There are four independent shafts, each one fitted with a single, solid, three-bladed propeller of 6ft. diameter and 6ft. pitch. Reversing turbines are incorporated into the exhaust ends of each of the low-pressure turbines. A reference to Fig. 1 will make clear the arrangement of turbines on shafts and the piping leads. A complete description of the Chester's machinery will be found in Volume XX., No. 2, of the Society's *Journal*. The high vacuum maintained is assisted by the use of the Parsons vacuum augmenter. Independent air pumps are installed with connections to the condensers through water seals. Reference is invited to Fig. 2. The vacuum augmenters are virtually steam jets so arranged as to siphon the air from the condensers at a point just above the water level and deliver it to the water seal for the air pumps to handle, at a pressure of from 1in. to $1\frac{5}{8}$in. of mercury higher than the condenser pressure. The discharge from the siphon passes through a small condenser for condensation and reduction in temperature. The system of lubrication installed provides for the supply of oil to thrust bearings, main bearings and spring bearings at a pressure of about ten pounds. The oil is supplied by steam-driven oil pumps and passes first through coolers on its way into the supply main. Separate pipes from the main pipe to the different bearings conduct the oil to the latter, and separate pipes take it away by gravity to common return mains which discharge into the oil tanks in the bottom of the engine-rooms. It is from these tanks that the oil pumps take suction. There are no valves in the system. The pipes which conduct the oil from the bearings have sight glasses in them so that the flow of oil may at all times be under observation, and at the same points thermometers are attached to indicate the temperature of the oil as it leaves the bearings. At one time small pressure gauges were fitted at each bearing to indicate the oil pressure, but these gauges are of doubtful value if the other methods are in use.

Warming the turbines for getting under way.—The utmost care must be exercised at this operation, as successful management depends more on it possibly than on any one other point. Much is heard about "blade stripping" in the Parsons turbine, its likelihood to occur, &c. It might be expected to happen if an attempt is made to run the turbines before they have been thoroughly and evenly heated, though probably the tips of the blades only would suffer. Except for this cause, or some such remote cause as a large bolt or nut finding its way into the turbine, stripping should never be expected in a properly constructed and well-balanced turbine. Thorough and even heating, however, is imperative, and no pains should be spared to see it done.

The length of time necessary to properly prepare the turbine for trial is greater than for the reciprocating engine. With care and practice it can, however, be reduced to a minimum so as not to compare unfavourably with the reciprocating engine. The safest practice is to allow plenty of time, except in emergencies, and to avoid any unnecessary competition. No definite period can be stated here, as it depends on the size and shape of the turbine and the facilities for uniform heating. Three hours and a half are usually allowed on the Chester from the time of beginning to warm up to the time of getting under way, though the turbines are generally tried and reported ready after three hours. They have been made ready in twenty-four minutes, and it is believed that they could be prepared in ten minutes. This, when it is considered that the Chester's brake horse-power is in the neighbourhood of 24,000, cannot be considered unreasonable. That which is to be avoided is local heating and consequent uneven expansion. An examination of the turbine shows that steam is admitted to a circular steam belt, and in consequence the steam takes its initial direction over all parts of the rotor drum at the same time, and toward the exhaust end. At the exhaust end the steam leaves the turbine at the one point on the side of the casing where the exhaust pipe is connected. For this reason it might be expected that the near side would benefit by steam of perhaps somewhat higher temperature than that on the far side; that is to say, at this end of the turbine. In order to counteract any ill effects which might result from such cause it is considered advisable to utilise the jacking gear while warming up, turning the shafts one quarter or one half a cycle every half hour. In order, too, that the greatest possible benefit may be derived from the heat of the steam, it is considered a wise practice to keep an extremely low vacuum, moving the air pumps as slowly as possible with safety. The various exposed parts of the turbine not covered by lagging should be felt with the hand from time to time, as much can be learned in this way as to the uniformity of heating. The use of auxiliary exhaust steam for warming up was at one time considered, but the idea was abandoned. On the Chester, connections from the auxiliary exhaust line are made to the second expansion of each main high-pressure turbine and into each low-pressure receiver pipe. On one occasion before the vessel was commissioned auxiliary exhaust steam was admitted to the port main high pressure in connection with warming it up, and the results were slightly disastrous, it being found when the turbine was tried that blades were rubbing in the second expansion. The casing was lifted later and an examination showed a few blades loosened and some bent on their tips, though the situation was not serious. This was caused by the unequal heating of this part of the turbine. In this connection, steam should be placed on the glands at the same time it is admitted to the turbines.

The general procedure of warming up the turbines on the Chester is as follows:—

(1) Open the drains of all turbines to the condensers and unseat all throttle valves and spring-loaded non-return valves.

(2) Open main injection valves and overboard delivery valves. Start main air and circulating pumps, having circulating connections open to the vacuum augmenter condensers.

(3) Crack the cross-connection valve in the communicating pipe between the auxiliary steam line and the main steam line in engine-room, thereby putting steam on so much of the main steam line as is in the engine-rooms. (This is done, as the main steam line in the fire-room spaces is quite extensive, and so much of it as is forward of the engine-room bulkhead stop valves is warmed up with the additional boilers to be used as steam is raised on them. This leaves the boiler in use for auxiliary purposes sufficiently powerful to warm the turbines without assistance.)

(4) Close turbine throttle valves and open throttle by-pass valves. Keep a low vacuum.

(5) Regulate pressure on auxiliary exhaust line, opening its connection to the steam gland system sufficiently to give a pressure on the glands of about 1 lb.

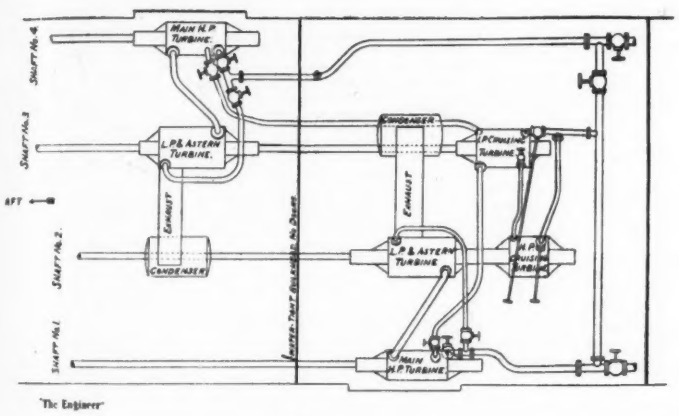


Fig. 1

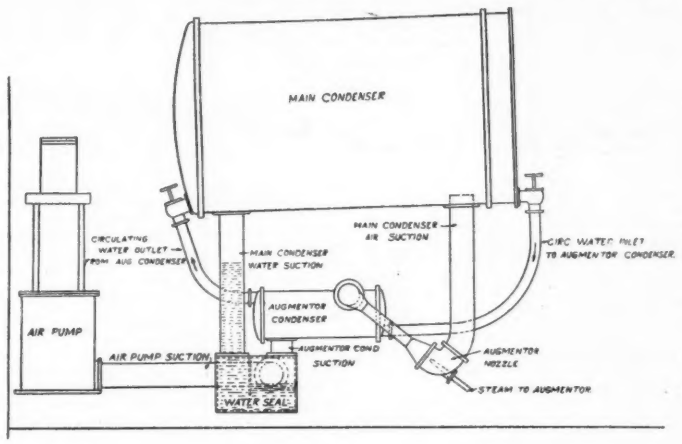


Fig. 2

(6) Examine the strainers on oil pumps and test both pumps. Note first the amount and condition of oil in the gravity return tanks; draw off any water that may be in the tank. See that water service is on the oil cooler and on the water jackets of the spring bearings.

(7) Steam having been raised on the additional boilers to be put in use, connect them, and open the engine-room bulkhead stop valves, closing the cross connecting valve between the main and the auxiliary steam lines. Close throttle by-pass valves, if desired, and continue warming up through the throttle valves partially unseated.

(8) The turbines being warm, a set of micrometer readings for dummy clearances should be taken and entered in the log.

(9) Open valves admitting steam to the vacuum augmenters. Disconnect jacking gear.

(10) Start oil pumps, by-passing the oil around the cooler. It should continue to be by-passed until the ship is under way and the oil has reached a temperature of 100 deg. Fah., otherwise it will be sluggish and fill the bearings with difficulty.

(11) Speed up the air and circulating pumps and raise the vacuum, and when a good vacuum has been obtained report the turbines ready for trial. Keep all drains open until well under way. When lying at anchor with banked fires and with orders to keep the turbines warm they should be jacked over at least once an hour. They remain warm a long time after securing, but steam should be kept on them. Fifteen minutes' notice is then considered sufficient.

Trying the turbines.—The turbines are tried separately at a low speed under light pressure, and if properly warmed they will move easily, and the chances of their giving trouble when opened out are none. In trying them "ahead slow" sufficient pressure should really be given the main high-pressure turbine to insure the turning of its accompanying low-pressure turbine by the exhaust of the former. This will not happen if the exhaust pressure is extremely low. On the Chester this is rarely done, as it results in giving the ship more motion than is desirable. The low-pressure turbines have never given trouble as a result. The test of the backing turbines is frequently repeated several times, it being the case very often that a rather high pressure is needed to turn them the first time. The cruising turbines should, of course, be tried out, but this, too, is omitted on the Chester, as it gives the ship too much motion. These turbines are so much smaller than the others that they are almost certain to be warm if the others are, and no difficulty has ever been experienced with them. If there is any interference of the blading in any turbine it will make itself evident by an intermittent rumbling or grinding noise which, if very serious, will be very shrill. The ears should be strained when the turbines are first tried in order to detect even the slightest noise, as a slight interference at such slow speed might increase and give trouble upon opening out the turbine. The internal noises of the turbine become magnified upon having placed the ear to one of the turbine casing guide rods, or by touching it lightly with the forefinger. (The guide rods referred to are standards fitted vertically at each corner of each turbine casing to assist in guiding the upper casing fair when it is being lifted, thus guarding against the blades of the casing engaging those of the spindle.) A pencil may also be held lightly against a guide rod or against some exposed part of the casing proper, and any interference inside can be detected by the resultant vibration. If at any time there is a reasonable doubt as to conditions the turbine should be stopped promptly and given more time to warm up. No more than fifteen or twenty minutes are apt to be lost by so doing.

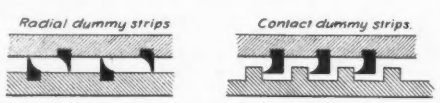


Fig. 3

Manœuvring, stopping and starting.—The turbines having been reported ready for use, signals from the bridge may be responded to with promptitude and dispatch. Manœuvring is accomplished with much greater ease than with the reciprocating engine, as there is no reversing gear necessary to operate or to fail of operation. The operation consists simply of the opening and closing of valves, and consequently but very few seconds are ever necessary. The mistaken idea held by some who are not familiar with the turbine, to the effect that manœuvring is a lengthy operation, is entirely without foundation. An example which I will cite should clear away any beliefs to the contrary. During the first fifty minutes that the Chester was under way after going into commission eighty-five signals were received from the bridge and each one was responded to. This was accomplished with a green crew, none of whom, including officers, had ever handled a turbine, and only three or four had ever seen one handled. The record was kept by a yeoman under my own personal direction and supervision, so I can vouch for each signal.

Full steam pressure may be admitted to the turbine as fast as the throttle can be opened, and the time occasioned to full open is but a few seconds. The valves should, most naturally, not be spun open with lightning speed, neither should they be opened irregularly by jerks. The turbines could hardly be expected to stand such treatment, but the valves may with perfect safety be opened smartly and with precision, and a sluggish response to a signal is entirely unnecessary. During periods of rest it is a good idea to admit an occasional blast of steam into the astern turbines for the purpose of keeping them warm. They act more efficiently when warmed up thoroughly, and the admission of light blasts of steam can be accompanied without turning the shafts. It can do no harm, even if an ahead signal is responded to at the time a blast of steam is passing in and before it is stopped. Due to the fact that the astern turbines are on the same spindle as the low-pressure ahead turbines, the dummy strips on the former must be of the radial type, whereas the latter are of the contact type. Fig. 3 illustrates the two types. The latter type permits of close and comparatively uniform regulation of the clearance, as will be explained later. The former type is a permanent adjustment and cannot be as efficient, as it must permit of more elastic limits. But one of the two dummies can have the type suited to adjustment, and it is, of course, most important that the ahead turbine should be the one so fitted. It is because of the type of dummy strips fitted in the astern turbines that more careful handling of these turbines is considered necessary. Injudicious handling of the astern turbine throttle valves is particularly to be avoided. The same degree of attention is paid to one throttle valve as to the other on the Chester, and no trouble has ever been experienced with the astern turbines from such cause—indeed, no trouble from any source has ever been had. No more time is necessary in handling the astern turbine than any other.

If a reverse signal is received from full ahead to full astern, no anxiety need ever be felt. The valve to the astern turbine may even be started open while the ahead throttle is being closed, and, as the combined act required so little time, the reversal may be considered as almost instantaneous. Such an operation requires careful judgment, and should not be attempted until the operators are thoroughly experienced and acquainted with the installation. The men assigned to stations at the throttle valves should be carefully selected, and be men of fair intelligence and sound judgment. A marked feature of the turbine lies in the fact that, while less labour is required in connection with it as compared with a reciprocating engine, more skill is required, for it is a much more delicate apparatus.

If running under cruising turbines, and a reverse signal is received, the execution of the signal involves no greater delay. Indeed, even less care is necessary than if the ship were running ahead under the main high-pressure turbines. This is because spring-loaded non-return valves are fitted in the exhaust pipes between the intermediate-pressure cruising turbine and each of the main high-pressure turbines. Steam is promptly cut off the cruising turbines, and at the same time the astern turbines' throttles are opened. Delay in attending to the former would cause no embarrassment, however, because of the valves above mentioned, which close automatically. In actual practice the non-return valve is usually closed by hand at the same time the remainder of the operation is being attended to. This should clear up any doubt as to occasion for accident due to the number of turbines in operation. The general practice on the Chester is to confine operations to the main turbines only, and allow the cruising turbines to revolve idly in a vacuum. It seems simpler, and that is considered sufficient reason. The cruising turbines are for economy at low speeds, and it might be thought that when manœuvring slowly the main turbines would prove wasteful, but the difference in economy is so slight that an hour or two of manœuvring would involve scarcely any appreciable loss.

Water in the turbines due to condensation or a result of priming need cause no apprehension. The drains are always open when manœuvring, and if the presence of water becomes known, it disappears almost as quickly as it comes. It is broken into small particles, and passes out with the exhaust steam in the form of spray, causing no damage. As the Chester's boilers furnish very dry steam, this has seldom occurred in her turbines. On one occasion it was noticed in the starboard low-pressure turbine an intermittent thump and pounding noise being heard for a few seconds, during which time the shaft slackened in its speed in jerks. The water cleared away without necessitating any action.

The inability of the turbine ship to compete with the ship fitted with reciprocating engines is a frequent argument against the adoption of turbines. The Chester receives her share of this

* From the *Journal* of the American Society of Naval Engineers.

criticism, and a great part of it is based on misunderstanding of conditions. All of her backing power is contained in two astern turbines, as previously mentioned. These turbines are of high-power design, and are in general uneconomical, this being partly due to their being of stunted dimensions with short blades, and partly due to the inefficient type of dummy strips which must be employed. For this reason high pressures of steam are most necessary to ensure successful results, but most important is the necessity for having a sufficient supply. Therein lies the difficulty in nearly every instance where backing is not entirely satisfactory. Usually when entering port the ship is under quite limited boiler power, and the boilers that are in use are incapable of supplying the steam without the assistance of the blowers. The use of the blowers is quite apt to be prohibited, owing to the increased supply of cinders which they help spread over the ship's upper deck. The natural result of such conditions is a weak response to backing signals, which it is not fair to blame the turbines for. With sufficient steam supply there should not be a marked difference between the backing qualities of the two types of vessels, though, of course, the small propellers and the high initial tip speed developed with the turbine installation must necessarily be some disadvantage. Again, the location of the two backing turbines on inboard shafts is bad for good results.

Operation when fairly under way.—Reference is again invited to Fig. 1 in connection with a brief description of the manner in which the turbines are used for economical performance at different speeds.

First, for low speeds—up to about 18 knots—the steam passes through all six ahead turbines, both the high-pressure cruising and the intermediate-pressure cruising being connected up with the four main turbines. Steam admitted to the high-pressure cruising exhausts into the intermediate-pressure cruising, and from the latter it exhausts through separate exhaust pipes to each of the main high-pressure turbines. From the latter it exhausts into the low-pressure turbines, thence into the main condensers.

Secondly, for moderate speeds—up to about 23 knots—the steam passes through five ahead turbines; being admitted to the intermediate-pressure cruising turbine, it exhausts, as before, into the main high-pressure turbines, thence into the low pressures and into the condensers. The high-pressure cruising turbine revolves idly in a vacuum, its drains being open to the condenser.

Thirdly, for highest speeds, only the four main turbines are used, steam being admitted to each main high-pressure turbine independently, and exhausting in each case through the connected low-pressure turbine and into the condenser. Both cruising turbines revolve idly in a vacuum, their drains being open to the condenser.

Reduction of power in each of the arrangements is obtained by throttling. Increased power is obtained by raising the pressure in the steam belt of the turbine which is being used as the initial stage. In the first arrangement additional power may be secured through the use of a by-pass valve from the first to the second expansion, and also by admitting live steam direct to the intermediate-pressure cruising or to the main high pressures. Similar increase in power may be obtained in the other arrangements. Ordinarily these alternatives are not used, though they are apt to be of benefit at any time.

An expansion coupling is fitted between the cruising turbines and the low-pressure turbine on the middle shafts. The forward end of the low-pressure shafts are built with twelve teeth, which engage with a slotted collar bolted to the flange coupling on the after end of the cruising turbine shafts. This permits of expansion at these points when the cruising turbines are connected, and permits of disconnecting the cruising turbines entirely. The couplings have always worked satisfactorily, but must be lubricated once a week. As but slightly increased efficiency can be expected from the main turbines with the cruising turbines disconnected, and as the joint is not easily broken, the coupling is always kept intact, and the cruising turbines when not in use are run idle in vacuo with drains open to the condenser.

The turbines should run without noise and without vibration. Such noises as have been mentioned above, if heard while the ship is under way, would indicate unusual conditions, which should be investigated immediately, as long, heavy turbines may whip slightly in a sea-way, due to the rolling of the ship or the racing of the screws. This might cause the blades to rub now and then, and the turbine to groan or vibrate slightly. In very bad weather it has happened to the main high-pressure turbines of the Chester, but not sufficiently to cause alarm, being barely noticeable. If the clearances of the dummies were very scant, the dummy rings might run a slight risk of grinding for similar reasons, but the likelihood of such an occurrence is very remote. Any grinding at this point would indicate too scant a clearance, and would be very serious, necessitating readjustment at first possible opportunity. To relieve such a situation as the latter, the speed should be changed so as to permit of running under the pressure which ensures the greatest clearance in this turbine. This should be known from records kept, as will be explained later. On the occasion of a trial trip, one of the Chester's main high-pressures came into zero clearance, and the dummy rings ground on the dummy slightly. At the time this turbine was under careful surveillance, so the situation was handled without difficulty. Clearances should not be carried so small, however, as to allow this to happen. Vibration may always be detected in connection with any such noises, but it is hardly perceptible unless the difficulty is very serious. Slight tremors may be felt when the astern turbines are operated, but they are not noticeable unless looked for. The whistling of wire-drawn steam through throttle valves may at first be mistaken for irregularities in the turbine, but a little experience soon makes it easy to distinguish.

It would appear that greater readiness for service should be expected of the turbine than of the reciprocating engine, as overhaul is so seldom necessary, and usually of a mild nature even then. Hardly any attention need be paid the turbine proper once it is under way, and no injury to attendants need ever be expected. The advantage resulting from the purity of the steam and its freedom from oil extends to the boilers, condensers, and feed-water heaters. Barely any cylinder oil is used on the auxiliaries in the engine-room of the Chester, a mixture of graphite and kerosene proving satisfactory for these engines.

In smooth weather a constant initial pressure, with a steady vacuum, corresponds to a constant speed, but varying conditions of wind and sea, or great variations in boiler pressure, have a detrimental effect in this respect. So long as the boiler steam is dry, no variation in initial pressure for a constant speed is necessary, but when, with a drop in pressure, the steam becomes wet, the effect is felt at once. For this reason the fire-room force must be trained especially to preserve fairly constant limits of pressure. The effect of wind and sea is really marked, and higher pressures become necessary for the same speed, with consequent loss in economy. This is against the turbine, but in spite of it the turbine ship is admirably fitted for heavy-weather work. The turbines do not labour or require throttling, but run with ease and adapt themselves freely to the changes. It may express their action best to say that they appear elastic under such conditions. The beneficial effect from having the wind astern is quite marked. The lower position of the centre of gravity due to turbine installations likewise is effective in securing increased stability.

With a sudden change in speed it is found that the turbine does not firmly establish itself to the new conditions for some considerable time. The proper pressure to carry for a specified number of revolutions per minute cannot be exactly determined for nearly an hour, though, of course, one suitable for the approximate speed can be found in a very few minutes, that is to say, within a quarter of a knot and less. Slight alterations in the pressure carried are apt to become necessary for several hours. More pressure is required before the turbine settles down than after it has become settled. A pressure-revolution table or pressure curve can only be used as a general guide, for such reasons as the above.

Running on a standard number of revolutions per minute is attended with the difficulty of ascertaining from time to time how many revolutions are being made. With four shafts, all revolving at a high rate, and two of the counters in one engine-room and two in another, mistakes are sure to be made. Besides, several minutes are required for the operation. A device connected with all of the shafts that would indicate at the working platform the general average at all times would be a most valuable aid to the throttling. Once the speed is established, however, it is maintained constant with comparative ease, though the man at the throttle must ever be at his station with his eye on the pressure gauge. It then serves to take counter readings about every twenty minutes. The Chester proved her efficiency as a guide ship in squadron on a recent run from Hampton Roads, Va., to Bradford, R.I. On this occasion a column formation was maintained, the Salem and the Birmingham steaming in their respective positions astern with an 800-yard interval. In spite of the marked difference in the types of machinery of the three vessels, perfect distance was preserved from beginning to the end of the run. The officers of the following ships were loud in their praise of the standard speed as preserved by the Parsons turbine. At the beginning of the run they noticed some unsteadiness in it, but when settled down none whatever was noticed.

The Chester picks up headway with lightning rapidity. While this to a large extent is due to the fineness of her lines, it is also due to the turbine installation. Manœuvring from rest should be harder with a ship having small propellers, but the turbines may be given steam so quickly and they reach their speed so quickly that I believe for quick ahead action they are, on the whole, superior. I would not like to say the same for astern motion, however.

(To be continued.)

CATALOGUES.

C. AND W. WALKER, Limited, Newport, Salop.—A useful blotter has been sent to us by this company.

JOHN W. BAINBRIDGE, 2, Fen-court, Fenchurch-street, E.C.—This is a circular dealing with pencils for marking on all kinds of goods.

WM. PRIESTLEY, Gloucester.—List No. 61 has reached us; it gives particulars of the second-hand machinery which this firm has in stock.

F. PATRICK, 15, Oxford-street, Leeds.—From this firm we have received a leaflet which has reference to the "F. P." machine starter or belt shifter. Illustrations, prices, and other particulars are given.

THE BRITISH, IRISH, AND COLONIAL DEPARTMENT OF THE MASCHINEN-FABRIK OERLIKON, Oswaldestre House, Norfolk-street, Strand.—This is a list which describes and illustrates an electric fire engine.

LACY-HULBERT AND CO., Limited, 91, Victoria-street, London.—Sheets Nos. 01, 02, and M are to hand from this company. They deal with the "Boreas" petrol-driven water pump, the Boreas rotary pump, and the Boreas air compressor respectively.

THE HART ACCUMULATOR COMPANY, Marshgate-lane, Stratford, London.—This company has sent us a well-bound catalogue which deals with "Hart" accumulators of various types and sizes, and also accumulator accessories. Instructions for working "Hart" batteries are included, and prices, dimensions, &c., are given in tabular form,

HASLAM AND SCHONTHEIL, *Western Mail* Chambers, Cardiff.—This is a price list dealing with the "Alpha" patented cable connector. These connectors, we are informed, are now being largely used by central station engineers, cable companies, power distribution companies, and collieries having electrical installations.

SALMON, WHITFIELD AND CO., Victoria Works, Kettering. London office, 10, Bush-lane, Cannon-street, London, E.C.—This is a descriptive pamphlet having reference to the Whitfield patented suction and suction-pressure gas plants. The pamphlet is well illustrated, and contains information which should prove of interest to power users.

WORTHINGTON PUMP COMPANY, Limited, 153, Queen Victoria-street, London, E.C.—We have received a copy of this company's new catalogue, which has reference to its patented centrifugal pumps. It is a well got up little publication, containing many excellent illustrations and information which should prove of interest to those who have to deal with the question of pumping.

WILLANS AND ROBINSON, Limited, Victoria Works, Rugby.—This company has sent us an interesting pamphlet, which deals with the Willans vacuum turbine. It gives some notes on the possibility of installing these turbines for working in conjunction with reciprocating engines, whether condensing or non-condensing. It also contains an illustration of one or two sets erected at the works of Sir Bernard Samuelson and Co., Middlesbrough-on-Tees. Illustrations of the rotors of turbines of this type are also given. The pamphlet is one which appeals to all large steam users, whether their engines run condensing or otherwise.

HENRY SIMON, Limited, Mount-street, Manchester.—Two sectional catalogues, sent us by this firm, one dealing with band conveyors, worms and creepers, and the other with elevators. Each contains admirable illustrations and particulars of nearly every possible type of apparatus of its kind. A third booklet is entitled "Types of Elevators, Silos and Grain Handling Plant," and contains illustrations and descriptions of a few typical examples of the many grain silos and grain handling installations which this firm is responsible for. We are requested to state that Messrs. Simon will supply copies to firms interested in the subject of handling grain.

J. HOPKINSON AND CO., Limited, Huddersfield.—Catalogue No. 660, second edition.—This is a well-arranged and compact publication of over 300 pages, and is divided into thirteen sections, as follows:—Section (1) General information; (2) standard specifications for Hopkinson's mountings; (3) safety valves; (4) high and low-pressure stop-valves; (5) boiler feed valves; (6) blow-off and scum valves; (7) water gauges and cocks, (8) pressure gauges, &c.; (9) isolating valves; (10) reducing and surplus valves; (11) expansion joints, steam dryers, &c.; (12) whistles, indicator cocks, &c.; and (13) is devoted to an index to code words, figure numbers, &c. The illustrations are very effectively produced.

THE ELECTRIC AND ORDNANCE ACCESSORIES COMPANY, Aston, Birmingham.—From this company we have received various catalogue sections, which are bound together in a substantial binder suitable for the bookshelf. Any section can readily be removed, if necessary, and new sections can be substituted. Among the things dealt with are controllers for cranes, tramways, polyphase motors, machine tools, &c., motor starters, ironclad combined quick-break lever switches and fuses, direct current control panels, "Ordnance" propeller fans, "Ordnance" centrifugal or cased fans, incandescent lamps, electric lighting accessories, porcelain insulators, the Warner cut meter for determining the speed of machine tools, telephones, &c. A separate section, which has just reached us, deals with desk, wall, ceiling, and port-hole electric fans for alternating and direct current circuits. Prices, dimensions and other particulars of interest to buyers are given in each case.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

The Latter Part of the Quarter.

THE quarter is drawing to a close in a somewhat quiet manner as regards new business, but deliveries are being made regularly under present contracts, and when inquiries are made quotations are maintained at the recent levels. The half-year now about to end has been only a moderate one for manufacturers, but business in some departments seems to have improved recently, and the outlook on the whole is better than it was. The continued good reports from America have a favourable effect here, and it is hoped that the Transatlantic trade revival, if such it be, will be continued. June is always a quiet month in the iron trade in this district, and the present is no exception to the rule. Stock taking operations have already been begun at several works.

Pig Iron Steady.

A steady tone marks the pig iron trade without any notable pressure. There is not much inquiry for future deliveries, but if there were, producers would hesitate to commit themselves in the present uncertainty as to the future prices of fuel, on account of the Mines (Eight Hours) Bill. Pig iron may be quoted at:—Staffordshire common, 46s.; part-mine, 48s. to 49s. 6d.; best all-mine, 80s. to 81s.; cold blast, 110s.; Northamptonshires, 46s. to 47s.; Derbyshire, 47s. 6d. to 48s. 6d.; North Staffordshire, 49s. to 50s.

Steel.

There is a fairly good demand for steel, both semi-finished and structural, and quotations are maintained at the following levels:—Bessemer sheet bars, £4 12s. 6d.; Siemens, £4 15s.; angles, £5 10s. to £5 15s.; girder plates, £5 15s. to £5 17s. 6d.; boiler plates, £7; joists, £5 10s. to £5 15s.; mild bars, £6 7s. 6d. to £6 17s. 6d.

Manufactured Iron.

There is a moderate trade being done in best bars at £8, with £8 12s. 6d. for Earl of Dudley's brand, and £7 for the second grade of the list houses. Unmarked bars vary from £5 15s. to £6, according to quality. The Galvanised Iron Trade Association have re-affirmed quotations at £12 10s., and the shipping trade continues satisfactory. There is a fair demand for black sheets at about the following rates:—Singles, £7 2s. 6d. to £7 5s.; doubles, £7 5s. to £7 7s. 6d.; trebles, £7 17s. 6d. to £8. Rivet iron is quoted £6 15s. to £7; slit nail rods, £7; gas strip, £6 5s. to £6 7s. 6d., and hoop iron, £6 17s. 6d.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Wednesday.

The Month's Pig Iron Trade.

TRADING during the past month has throughout been on the side of the buyer, and the close is exceedingly weak. Indeed, prospects forward are by no means good, and the recent fall in Stock Exchange securities as well as an absence of speculation has adversely affected all classes of iron. One encouraging feature, however, is the fact that shipments continue good from East and West Coast ports, and hematite especially has shown some improvement in the demand, and closes firm at full rates to 6d. per ton dearer on the month. On the other hand, Middlesbrough is 3d. to 6d. per ton lower; Scotch is also fully 6d. lower, but in Lincolnshire and Derbyshire there is not much change to note. On the Iron Exchange here on Tuesday there was a good attendance, but buyers were in a minority and actual business was on a small scale. The balance of opinion was against any improvement in the market for some time to come, although, on the other hand, there were optimists who predicted an improvement in the course of a month or so. It is hoped for the sake of the iron trade that these predictions will be fulfilled.

Finished Iron and Steel.

There was a quiet feeling, with little or no change in quotations.

Copper, Brass, &c.

Sheets continue unchanged, but tubes are ½d. per lb. lower on the week. The reduction, however, has not stimulated business to any great extent. Brass tubes are unchanged. Lead: Sheets very steady. Tin: English ingots were a shade firmer.

Quotations.

Pig iron: Lincolnshire No. 3 foundry, 52s. to 52s. 6d.; Staffordshire, 51s. to 51s. 6d.; Derbyshire, 52s. 6d. to 53s.; Middlesbrough, open brands, 57s. 7d. Scotch: Gartsherrie, 58s.; Glengarnock, 57s. 6d.; Eglinton, 56s. 9d. to 57s.; Dalmellington, 56s. 9d. to 57s., delivered Manchester; West Coast hematite, 58s. 6d.; East Coast ditto, 55s. 6d., both f.o.b. Delivered Heysham: Gartsherrie, 56s.; Glengarnock, 55s. 6d.; Eglinton, 54s. 9d. to 55s.; Dalmellington, 54s. 9d. to 55s. Delivered Preston: Gartsherrie, 57s.; Glengarnock, 56s. 6d.; Eglinton, 55s. 9d. to 56s.; Dalmellington, 55s. 9d. to 56s. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 15s. to £8. Steel: Bars, £6 5s. to £6 10s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler plates, £7 2s. 6d.; plates for tank, girder, and bridge work, £6 to £6 5s.; English billets, £4 10s. to £4 15s.; foreign ditto, £4 2s. 6d. to £4 5s.; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £73; tough ingot, £63; best selected, £63 per ton; copper tubes, 9¼d.; brass tubes, 7⅞d.; condenser, 8⅜d.; rolled brass, 6¼d.; brass wire, 6⅜d.; brass turning rods, 6¾d.; yellow metal, 6½d. to 6¼d. per lb. Sheet lead, £17 5s. per ton. English tin ingots, £131 10s. per ton.

The Lancashire Coal Trade.

There was a rather meagre attendance on the Coal Exchange, but discussion turned mainly on the coming into operation of the Eight Hours Act. So far as could be gathered, some collieries have already commenced working under its provisions, so that it would appear that Lancashire will not be greatly affected. Whether there will be an official advance in prices at the beginning of July remains to be seen, but in view of the slackness of trade in Lancashire it is not very probable. Quotations are as follows:—Best Lancashire coal for domestic purposes, 14s. 2d. to 15s. 8d.; seconds, 12s. 2d. to 13s. 2d.; common, 9s. 2d. to 11s. 2d.; best burgy, 10s. 6d. to 11s. 6d.; round furnace coal, 11s. to 11s. 6d.; best slack, 9s. to 10s.; medium, 8s. 6d. to 8s. 9d.; common, 7s. 6d. to 8s. at the pit. Coal for bunkering purposes, screened, 11s. to 11s. 6d.; unscreened, 10s. 6d., delivered Manchester.

BARROW-IN-FURNESS, Thursday.

Hematites.

The hematite iron market is a shade weaker, and business has to some extent fallen off, but makers have not for the moment been affected by this depression, as the orders they have on hand are keeping them going, and they anticipate they will be able to continue their present output of metal without resorting to any increase in stocks. The latter have kept very low for some time past, and it is to the interest of makers that they should continue

to do so, as in the event of a better market being experienced holders of stocks would participate in the improvement in price and, to some extent, in the fixing and maintenance of that price. Makers are quoting 58s. net f.o.b. for mixed Bessemer numbers, and 60s. to 61s. 6d. for special hematite, according to specification, while warrant iron is at 56s. 6d. net cash sellers. A fair amount of attention is being devoted to special hematite iron at present, and there are both home and foreign buyers. In spiegeleisen there is only a moderate trade, but a fair business is being done in ferro-manganese. Charcoal iron is selling in small parcels. The demand for scrap iron is not brisk. Iron ore sells only in moderate parcels at old prices, ranging from 11s. to 17s. per ton, according to quality. A large tonnage of foreign ore is being smelted in the district.

Steel.

There is no improvement in the demand for steel, and orders are coming to hand slowly for railway material. The Barrow Steel Works, after a week's stoppage, recommenced operations on Monday. In merchant steel very little is being done, while the inquiry for shipbuilding material is very quiet indeed.

Shipbuilding and Engineering.

With the launch of the Canadian ice-breaking steamer Earl Grey last week from the yard of Vickers, Sons and Maxim at Barrow, only one vessel in course of construction was left on the stocks, H.M. cruiser Liverpool. The firm, however, is negotiating for new orders, and expects to get them. Engineers are not doing much in marine work, but they are getting ready for what promises to be a very active time in the gun-mounting department.

Shipping and Coal.

The shipping returns of West Coast ports continue to show improvement in iron and steel exports. Last week the shipments amounted to 10,658 tons—iron 4552 tons and steel 6106 tons—as against 7903 tons for the corresponding week of last year, an increase of 2755 tons. For the year to date the shipments aggregate at 289,120 tons, against 243,743 tons for the corresponding period of last year, an increase of 45,377 tons.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Business Situation.

We are approaching the end of the half-year without experiencing that improvement in industrial affairs which it was hoped would have been reached by this time. Business continues quiet in the heavy trades. The languid condition of the iron market is in a measure due to the stock-taking which is pretty general at this season, and deliveries of raw material are consequently restricted as much as possible until June is out, and, in some instances, will not be freely resumed until about the second week in July. In the coalfield the holding of the Yorkshire miners' demonstration last Monday at Sheffield threw a little more work on to the close of last week. Business, however, is not much affected by this great annual gathering. There is at present no great pressure of orders, and the event is known so long before that any little pressure may be anticipated the week before. The Yorkshire collieries were set down on the Monday for the gathering as usual, but work was fairly well resumed on Tuesday morning.

The Coal Trade.

In domestic fuel the changeable weather keeps consumption at rather over the average for the season of the year. Quotations previously given are maintained, and, so far as can be seen, prices are not likely to be reduced in the near future. Deliveries to London and other southern markets are very good, and a similar remark holds with regard to the Eastern Counties. Best qualities are most in request. The briskest business is in steam coal, the export trade being well maintained at 6d. per ton over the contract rate, which was 8s. 6d. per ton. Gas coal contracts, which, with very few exceptions, are made for the twelve-months, continue to be arranged on the basis of 6d. per ton less than last year's rates. Gas contracts usually occupy attention until about the middle of July.

Small Coal and Coke.

For best qualities of small coal the demand is active, and former quotations are easily maintained. The Lancashire cotton and Yorkshire woollen mills receive supplies fully up to the average weight at from 4s. 6d. to 5s. 6d. per ton. Coking qualities are also in request. Coke is fairly called for, best washed fetching 10s. 6d. to 11s. per ton; unwashed, 10s. to 10s. 6d. per ton, the higher prices for coke being freely obtained.

Iron Quotations.

While there is no improvement to report in prices, there is no decline. The iron market, more than others, is affected by the stock-taking generally carried on at this season of the year at the various consumers' works, and deliveries are therefore not very large. On the other hand, ironmasters, with the reduced output, are able to retain the iron which would ordinarily be delivered without forcing it on the market. Hematites, West Coast, 68s. to 69s. per ton; East Coast, 64s. to 65s. per ton—both less 2½ per cent., delivered in Sheffield and Rotherham. The Lincolnshire Ironmasters' Association met last Friday, but made no alteration in official quotations, which remain as follow:—No. 3 foundry, 50s. per ton; No. 4 foundry, 49s. per ton; No. 4 forge, 49s. per ton; No. 5 forge, mottled and white, 49s. per ton; basic, 50s. 6d. per ton. Derbyshire, No. 3 foundry, 50s. per ton; No. 4 forge, 49s. per ton. Lincolnshire and Derbyshire irons are net, delivered in Sheffield and Rotherham.

Bars, Hoops, and Sheets.

The condition of the finished iron trade is not more satisfactory than last reported. Orders for bars are quite inadequate to afford full employment for the week, while there is no prospect, as trade is now, of any early opportunity of raising prices to a more profitable level. The hoop business is also languid. Bar iron, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

Steel, Files, &c.

Further increased buying from the United States is the most encouraging feature at present in the steel trade, but that, as we pointed out last week, is confined to the high grades of steel, more particularly of high-speed qualities, and the tools produced from them. With the settlement of the American Tariff Bill it is expected an important change for the better will be brought about. Orders have been suspended while the tariff question has remained in a state of uncertainty, and the definite decision of the points at issue will, it is anticipated, release a considerable amount of trade now in abeyance. Makers of twist drills in high-speed are doing a fair business, orders coming steadily forward. Very little is being received from engineering establishments regarding files, but the Admiralty requirements are finding a considerable amount of employment, the specifications for early delivery being heavier than usual. The cycle trade has of late been more active, and this has caused a larger consumption of steel used in the various parts of the machine. This remark also applies to the motor industry, particularly in respect of castings. This trade, however, is not heavy as regards weight, and is, for the most part, in the hands of a few firms who have made it a speciality.

John Brown and Co., Limited.

The annual report of John Brown and Co., Limited, Atlas Works, Sheffield, for the year ending 31st March last, has been issued. The directors state that "owing to the limited demand for armour and general trade depression, the operations at the Atlas Works were not so profitable as in the previous years. Consequent on the serious fall in steam coal prices, results at the collieries have been disappointing. A large output, however, has been obtained, and every effort is being made to keep down the working costs. The trials of H.M. first-class cruiser Inflexible were very satisfactory, and the vessel has been added to the British Fleet. Orders have been received for a second-class cruiser, three destroyers, and the machinery and boilers for H.M. first-class cruiser Indefatigable. A large steamer has recently been delivered to the Orient Steam Navigation Company for their new Australian mail service. The directors regret that no orders have as yet been received for heavy gun mountings by the Coventry Ordnance Works, and consequently much valuable plant has been idle during the year. With this exception the results of the operations of the various subsidiary concerns in which the company has an interest have been fairly satisfactory." The report further states that arrangements have been made for the acquisition of the greater part of the ordinary and preference share capital of the Dalton Main Collieries, Limited. These collieries are contiguous to the Aldwarke and Rotherham Main, and the arrangement will, in the opinion of the directors, be of both direct and indirect advantage to the company.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

No indications of improvement can be reported in connection with the Cleveland pig iron trade, for the continuous downward movement in prices is keeping consumers and speculative buyers out of the market. The increasing stocks are also weakening the position, and as what is usually a dull time of the year is at hand, people are in no hurry about buying, while some of the second hands are rather anxious to sell, so as to clear out and probably lose less than if they held on. The intelligence from the United States about a revival of trade there does not yet favourably influence the situation here. There can hardly be any doubt that business is more satisfactory in the States, for production increases rapidly, and advances of wages are reported even up to 10 per cent., but the commercial news from the Continent neutralises the influence of the better reports from America, and some traders in this district do not look forward very hopefully, though it is to be noted that there is a premium of 7d. to 8d. per ton on the prompt price for Cleveland warrants for delivery in three months, and, moreover, this week several of the Cleveland ironmasters have sold No. 3 for delivery over the second half of the year at 49s. per ton f.o.b., which is 9d. per ton more than has been realisable for prompt delivery. That is a favourable feature. Cleveland pig iron warrants have this week been as low as 48s. 2d. cash buyers, which is a lower figure than has been reported for more than a month. The price of No. 3 Cleveland G.M.B. pig iron has dropped to 48s. 3d. per ton for early f.o.b. delivery, while No. 1 is at 50s. 9d., No. 4 foundry at 47s. 3d., and No. 4 forge at 47s.

Hematite Pig Iron.

The situation of hematite pig iron makers in this district is very unsatisfactory; in fact, it may be said they are feeling the depression more than those engaged in any other branch of the iron and steel industries, and it would not be easy to find a producer who can realise a profit under the circumstances that now prevail, the cost of materials being out of proportion to the price that can be obtained for the pig iron. It is reported that makers hold considerable stocks, the production having for some time been in excess of the requirements. Makers in some cases say that if there is not an early revival in business it will be necessary to blow out furnaces. A first step in that direction will, in fact, be taken next week, for on Wednesday William Whitwell and Co., at the Thornaby Ironworks, Thornaby-on-Tees, will commence to blow out one of their three furnaces—all producing hematite iron. They will take advantage of the slackness of trade to re-line the furnace. Other firms will probably, with advantage to themselves and the trade generally, follow Messrs. Whitwell's example. Certainly makers need some relief in the cost of ore and coke, and a reduction of the consumption of these appears to be the best way to bring about the cheapening of materials. The advantage of making iron at a loss to put into stock cannot be considered advisable. The price of mixed numbers of East Coast hematite pig iron is down to 55s. per ton for prompt delivery, makers as well as second hands taking that, while for delivery up to the end of August 55s. 6d. is quoted. Rubio ore is obtainable at 16s. per ton delivered in the Tees, but merchants mostly ask 16s. 3d., and cannot well afford to sell at less, seeing the rates they have to pay to the Spanish mine-owners, who are the "masters of the situation." Coke is certainly somewhat easier than it was; in fact, there have been sales this week at 15s. 3d. per ton delivered at Middlesbrough furnaces, though 15s. 6d. is the general quotation. The demand for coke is short of the production, and there are considerable stocks at the collieries.

Pig Iron Stock.

It is unsatisfactory to note the continued increase in the stock of Cleveland pig iron in Connal's public stores, recognising that at the same time the stocks in makers' yards are also accumulating. Owing to this merchants can readily buy Cleveland pig iron for immediate shipment. It is curious to remark, however, that with so much iron in stock there is so little pressure among producers to sell. Connals on Wednesday reported that they had 233,651 tons of Cleveland pig iron in their stores, an increase this month of 12,573 tons, and only on a single day has there been a decrease recorded. The stock consisted of 228,546 tons of No. 3 Cleveland pig iron; 4500 tons of No. 4 foundry; and 605 tons of other iron not deliverable as standards.

Pig Iron Shipments.

Though there has been some improvement in shipments of pig iron from the Cleveland district during the last few days, the month's exports are not as good as might be looked for, and are not equal to those reported in April. During the next two months they are likely to be poor, as July and August are usually quiet shipping periods, and demands from the Continent are very slack, and judging from the reports of those who have been making business tours in Germany, are likely to continue so, except to Italy. Deliveries to Canada are improving, and as trade is reviving in the United States it is regarded as not improbable that the shipments from Cleveland to that market may before long become brisk. The production of pig iron in the United States, which was last year 40 per cent. less than in 1897, has lately been greatly increased, and is now at a rate almost equal to that of the year before last, when Cleveland sent nearly a quarter of a million tons of pig iron for the use of the ironfounders of the States. The quantity of pig iron exported from the Cleveland district this month to Wednesday night was 86,442 tons, compared with 83,735 tons last month; 92,115 tons in June, 1908; and 123,250 tons in June, 1907, all to 23rd.

Finished Iron and Steel.

Generally producers do not speak well of business, they could do with a good many more orders than they are securing, for those which they are able to get do not suffice to keep the works regularly employed. The rail mills are the most fully occupied, and exports of steel rails are larger, as also are those of galvanised sheets, extensive supplies of which are shipped to India, Japan and South America, to which countries regular lines of steamers now run from the Tees. For heavy steel rails the prices are not below £5 5s. per ton net f.o.b. Black sheets are firm at £7 7s. 6d., less 2½ per cent. f.o.t., and galvanised and corrugated iron or steel sheets, 24 w.g. in bundles, are quoted at £12 10s., less 4 per cent. f.o.b., or 2½ per cent. f.o.t. Steel joists are £5 7s. 6d. to £5 15s., less 2½ per cent. according to quantity, small lots being at the higher figure. The demand for joists has been quiet, but now shows some improvement. The reductions made in the quotation for shipbuilding materials have not brought out buyers, for the increase of business in shipbuilding is of very small extent, and apparently no reduction that manufacturers can make will lead to the distribution of orders for shipbuilding materials. Steel ship plates can be got at £5 15s., less 2½ per cent., by home consumers, but £5 12s. 6d., less 2½ per cent., will be accepted for export orders, thus giving an advantage to the foreign consumer, as is the case in connection with galvanised sheets, the foreign consumer being allowed a bigger discount. Steel bars are at £6 5s. and iron bars at £6 15s., both less 2½ per cent. f.o.t. Iron bars at £6 15s., both less 2½ per cent. f.o.t. Steel hoops are in growing request, and the makers are able to get £6 10s., less 2½ per cent., for them, while steel nail strip is at £6 7s. 6d., less 2½ per cent.

Ironfounding.

Those engaged in ironfounding in this district have lately experienced a very bad time, prices being such as hardly allow of profits being realised; indeed, concerns which in past years have never missed paying dividends have been unable to declare any for the last half-year, and works are kept going very intermittently.

The Eight Hours Act.

The Cleveland mineowners and their men have come to an arrangement about the application of the Act at the Cleveland ironstone mines which is to come into force next week. The arrangement is to continue in force as an experiment for three months, and if it does not answer some other arrangement will be devised. The Act will not apply to the collieries of Durham and Northumberland until January 1st next.

Coal and Coke.

Business in the coal trade of Durham and Northumberland has slackened after a very brisk time and high prices over the spring. It is usual for trade to become quieter at this season of the year, but it was thought that the threatening state of affairs in Wales and Scotland would have kept business in the North-East of England in an inflated condition. Prices are certainly becoming easier, especially for steam coal, and second hands are rather anxious sellers, as the longer they hold on the less money they are likely to have to take. In the spring 13s. per ton was regularly realised for best steam coal, this week 11s. 9d. has been the figure, and seconds have dropped to 10s. 9d. Best gas coals have not been so detrimentally affected, and the fall in prices has been of smaller extent—10s. 9d. f.o.b. being asked, with 10s. for seconds. Bunkers are easier, 9s. 9d. per ton being taken. Coke is in abundant supply, and the price of furnace coke is down to 15s. 3d. per ton delivered equal to Middlesbrough, while foundry coke is at 16s. 6d. f.o.b. This week most of the collieries on Tyneside have been stopped for the annual holidays, which are given in Newcastle race week. The miners at Wingate Colliery have decided against agreeing to the co-partnery scheme which Sir Christopher Furness proposed for their acceptance.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

Arrested Improvement of Trade.

Not a few signs were visible several weeks ago of an improving tendency in trade, and the movement appeared to derive considerable stimulus from activity in the metal and share markets. These latter have now become less active, and in Scotland especially stock business has fallen away to a remarkable extent. At one time it looked as if there would be a small boom in trade before the annual holidays; but now there is no prospect of such a thing, as the holidays commence in the principal industrial centres in the course of the next three weeks. There is general concurrence in the opinion that, so far as Scotland is concerned, the chief cause of the arrested improvement in trade is the action of the miners' leaders in threatening a general strike on the wages question, the settlement of which they have declined to submit to arbitration. They want to raise the basis limit of wages from 5s. 6d. to 6s. per day, and the time they have chosen for such a purpose is about as inopportune as possible, when it is certified that in Glasgow alone there are from 40,000 to 50,000 operatives out of employment. The prices of manufactured goods have been steadily declining, and many works are either wholly or partially idle, and it is at such a time that the miners' advisers have decided upon measures likely to raise the cost of production, and still further postpone the long expected improvement in trade. Merchants and manufacturers are compelled to restrict their operations to spot business, and such things as contracts extending over a period are scarcely to be entertained in any connection.

The Pig Iron Market.

The Glasgow iron market has been very quiet throughout the greater part of the week, and at some of the meetings of the iron ring no business whatever was transacted. Speculative dealings are being restricted, and there is now little likelihood of a revival of this class of business for some time to come. Cleveland warrants have been done at 48s. 8d. to 48s. 3½d. cash, 48s. 5d. for delivery in thirteen days, 48s. 8d. to 48s. 5½d. one month, and 49s. 3d. to 48s. 10½d. three months. A larger proportion of the business than usual has been for delivery in three months, cash transactions being comparatively limited.

Scotch Makers' Iron.

The output of Scotch pig iron is maintained, there being eighty-two furnaces in blast, compared with seventy-seven at this time last year. Of the total, thirty-nine furnaces are making ordinary, thirty-eight hematite, and five basic iron. The foreign demand for Scotch pig iron is quiet. Lately there have been fair shipments to Canada, and an increased quantity of Scotch pig iron sent to Germany, but it is regarded as doubtful whether the improvement noted in the German demand is likely to continue. At any rate, the advices from Germany are of an unsatisfactory nature. Those from the United States, on the other hand, continue favourable, but the American demand for Scotch pigs, which showed some expansion a short time ago, has recently fallen away, and in some weeks no iron whatever has been exported thither. This has been so in the past week. Home requirements are small, purchases being generally of a hand-to-mouth character. There has been comparatively little change in prices of makers' pig iron. Monkland, f.o.s. at Glasgow is quoted No. 1, 56s.; No. 3, 54s.; Carnbroe, No. 1, 57s. 6d.; No. 3, 54s. 6d.; Clyde, No. 1, 60s.; No. 3, 54s.; Gartsherrie, No. 1, 60s. 6d.; No. 3, 54s. 6d.; Calder, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Summerlee and Langloan, Nos. 1, 61s.; Nos. 3, 56s.; Coltness, No. 1, 88s.; No. 3, 56s.; Glengarnock, at Ardrossan, No. 1, 63s. 6d.; No. 3, 57s.; Eglinton, at Ardrossan or Troon,

No. 1, 55s. 6d.; No. 2, 53s. 6d.; Palmellington, at Ayr, No. 1, 58s. 6d.; No. 2, 53s. 6d.; Shotts, at Leith, No. 1, 60s. 6d.; No. 3, 55s. 6d.; Carron, at Grangemouth, No. 1, 63s.; No. 3, 56s. per ton.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week were small, amounting to 4900 tons, compared with 6136 in the corresponding week of 1908. To Canada 573 tons were despatched, South America 90, India 145, France 15, Italy 40, Germany 850, China and Japan 200, other countries 201, coastwise shipments being 2784 tons against 2610 in the same week of last year. The arrivals at Grangemouth of pig iron from Cleveland and district amounted to 10,252 tons, being 2412 tons more than in the corresponding week.

The Hematite Trade.

A fleet of twenty steamers arrived in the Clyde during the past six days with iron ore, three of the vessels being from the North-west of England and the rest from abroad. The amount of the output of hematite pig iron in Scotland at present is about 13 000 tons per week, being 1000 tons weekly less than at this time last year, and it is understood that a good proportion of the iron is still going into store. The current demand for hematite is small, but prices are, if anything, a shade firmer. Cumberland hematite warrants have this week been quoted in Glasgow markets 57s. 1½d. to 57s. 4½d. per ton, and merchants quote Scotch hematite 57s. 6d. for delivery at the West of Scotland steel works.

Finished Iron and Steel.

The depression in these branches is only partially relieved by a desire to have the available work pushed through in anticipation of trade holidays, and also to provide for the inconvenience of a possible stoppage of work in the coal trade. For light structural steel material there has been a fair demand, but specifications for shipbuilding material do not come forward as could be desired. There is considerable activity in some departments of the engineering trade, and pipe founders in some instances report more favourably regarding the state of business. Reports concerning the condition of the malleable iron trade are still unfavourable, and only partial employment is obtained at the works.

The Coal Trade.

The shipments of coal from the Scottish ports as a whole show a great improvement, the advance being chiefly on the East Coast. The markets have been firm, with an upward tendency in prices. In the last day or two, however, there has been a disposition to slackening of demand in some districts, as buyers are more inclined to await the result of a conference on the wages dispute, which is to be held in Glasgow in a few days between representatives of the Scottish coalmasters and a deputation of officials of the Mining Federation of Great Britain. Coal is quoted, f.o.b. at Glasgow, ell, 9s. 3d. to 9s. 9d.; steam, 9s. 6d. to 9s. 9d.; and splint, 9s. 6d. to 10s. per ton. The demand for home consumption is quiet as regards household coal.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THE fear of a coming strike brought two special features to the front last week. First there was a falling off in the inquiry, and it was evident that coal was being sought for in various new quarters, with the result that coal which in the general course of things would have been had in Wales had been obtained elsewhere. Another new feature was that dealers who were known to hold chance lots of coal found it impossible to sell at a price. This, to the alert mind of buyers, indicated that fears of a strike were not so strong as they had been, and also there was increasing tendency to a droop in price. On the whole best coals were weaker last week by 3d. a ton. Should the present block be removed, and the current of the coal trade be freed from its obstacles, a good time is certain.

Latest Prices at Cardiff.

The air is so full of rumours and surmises that it is difficult to comment or anticipate events, especially as the deliberations of the conference now being held in Cardiff may at the close of any meeting end in a complete upset of business relations, or, that quite as likely, in a general agreement. Pending results, the undertone when our despatch was sent was easier; inquiry for large not sustained; dry coals' figures remain; small not so firm; quotations for Monmouthshire sustained; house coals only moderate; and it was very evident that the usual movement of the season had not begun. Latest: Best large steam, 17s. to 17s. 6d.; best seconds, 16s. 3d. to 16s. 6d.; ordinary seconds, 15s. 6d. to 15s. 9d.; best drys, 17s. to 17s. 3d.; ordinary drys, 14s. 6d. to 15s.; best washed nuts, 14s. to 15s.; seconds, 13s. to 13s. 6d.; best washed peas, 12s. 6d. to 13s.; seconds, 11s. to 12s.; very best smalls, 11s. to 11s. 6d.; best ordinaries, 9s. 9d. to 10s. 3d.; inferior sorts, 8s. 9d. to 9s. 3d.; very best Monmouthshire, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 9d. to 15s.; best Eastern Valleys, 13s. 3d. to 14s.; seconds, 12s. 9d. to 13s. Bituminous coal: Very best households, 16s. 6d. to 17s. 6d.; best ordinaries, 14s. 6d. to 15s. 6d.; No. 3 Rhondda, large, 17s. 9d. to 18s.; brush, 13s. 6d. to 13s. 9d; smalls, 9s. 6d. to 10s. 3d.; No. 2 Rhondda, large, 12s. 9d. to 13s.; through and through, 10s. to 10s. 6d.; smalls, 8s. 9d. to 9s. Patent fuel, 16s. to 16s. 6d. Coke: Special foundry, 24s. to 26s.; foundry, 18s. to 20s. 6d.; furnace, 16s. to 17s. Pitwood, 18s. 3d. to 18s. 9d. Iron ore c.i.f. Cardiff or Newport: Rubio, 15s. 9d. to 16s.

Newport Prices.

Business was very restricted mid-week, and it was reported that nothing was being done for July. Buyers and sellers are waiting the result of negotiations at Cardiff. Steam coal: Very best Newport black vein large, 15s. to 15s. 3d.; Western Valleys, 14s. 6d. to 14s. 9d.; Eastern Valleys, 13s. 3d. to 13s. 9d.; other sorts, 12s. 6d. to 12s. 9d.; best smalls, 9s. to 9s. 6d.; seconds, 8s. 3d. to 8s. 9d.; inferiors, 7s. 9d. to 8s. Best house coal, 15s. to 15s. 3d; seconds, 14s. to 14s. 3d. Patent fuel, 14s. 6d. to 14s. 9d. Coke: Foundry, 17s. to 17s. 6d.; furnace, 16s. to 16s. 6d. Pitwood (ex ship), 18s. 3d. to 18s. 9d. Iron ore, c.i.f. Newport. Rubio, 15s. 9d. to 16s. Coal prices, f.o.b., less 2½ per cent., cash in 30 days.

Swansea Coal.

As expected, compass of business continued within narrow limits. Swansea large coal and anthracite rubbly culm are in good demand, and difficult to obtain; higher prices ruling, and most qualities are ruling firm. Anthracite coal: Best malting, large, hand-picked, 23s. 6d. to 24s. 6d. net; second malting, large, 21s. 6d. to 22s. 6d. net; big vein, large, 19s. to 21s., less 2½ per cent.; red vein, large, 13s. to 13s. 6d., less 2½ per cent.; machine-made cobbles, 23s. 6d. to 24s. net; Paris nuts, 23s. 6d. to 25s. net; French nuts, 23s. 6d. to 25s. net; German nuts, 23s. 6d. to 24s. 6d. net; beans, 16s. 3d. to 16s. 6d. net; machine-made large peas, 11s. 6d. to 12s. 6d. net; machine-made fine peas, 8s. 6d. to 10s. 6d. net; rubbly culm, 6s. 6d. to 7s., less 2½ per cent.; duff, 3s. to 3s. 6d. net. Steam coal: Best large, 15s. 6d. to 16s., less 2½ per cent.; seconds, 13s. 6d. to 14s. 6d., less 2½ per cent.; bunkers, 11s. 6d. to 12s., less 2½ per cent.; small, 9s. to 10s. 6d., less 2½ per cent. Bituminous coal: No. 3 Rhondda, large, 18s. to 18s. 6d., less 2½ per cent.; through and through, 15s. 3d. to 15s. 6d., less 2½ per cent.; small, 9s. to 10s. 6d., less 2½ per cent. Patent fuel, 14s. 9d. to 15s., less 2½ per cent. Coal quotations are all f.o.b. net cash 30 days.

Iron and Steel.

There were more cargoes of iron ore last week, principally from Bilbao, and one from Caen; pig iron came in from Whitehaven and Grimsby, but only one despatch of rails of any consequence. This was from Cardiff, about 3000 tons of rails forming part of the consignment on India State Railways account. In the works there is a degree of activity, though not to the same extent as lately, and the opinion expressed by the leading men is that the condition of things is being largely affected by the state of the coal trade. Once let the coal trade be free from the rumours of strikes, and an earnest would be given for steady business and for completing developments in the steel works. The stoppage of the Siemens has now lasted eight weeks. One result of this has been the reduction to a day's run of the Bessemer. Urgent needs for fishplates exist at Dowlais, sleepers and heavy rails are in demand, engineering and mechanical shops busy.

Latest Prices at Swansea.

Hematite, mixed numbers, per ton, 57s. 4½d. cash and one month; Middlesbrough, 42s. 2½d. cash, one month; Welsh hematite, 62s.; East Coast hematite, c.i.f., 60s. 6d. to 61s. 6d.; Bessemer, £4 10s.; Siemens steel bars, £4 10s. Other quotations:—Block tin, per ton, £132 15s. cash, £134 2s. 6d. three months; copper, per ton, £58 5s. cash, £59 2s. 6d. three months; lead, £13 12s. 6d.; English, Spanish, £13 2s. 6d.; spelter, £22 per ton; silver, 2s. 1½d. An average production of pig iron is being made at Landore and in steel the same number of furnaces were busily worked as in last week. Full time at the spelter, and at the three copper works.

Tin-plate.

The quantity of tin-plates received from works last week totalled 102,707 boxes; shipped during the week, 109,954 boxes; stocks remaining at docks, 204,868 boxes. Latest prices on 'Change, Swansea:—Ordinary tin-plate, I.C, 60 by 14, 112 sheets, 108 lb; Bessemer primes, 12s. to 12s 1½d.; wasters, 11s. 3d. to 11s. 4½d.; Siemens primes, 12s. to 12s. 1½d.; wasters, 11s. 3d. to 11s. 4½d; C.A. roofing sheets, £8 7s. 6d. per ton to £8 12s. 6d.; big sheets for galvanising, £8 7s. 6d. to £8 12s. 6d.; finished black plates, £9 5s. to £9 10s.; galvanised sheets, 24 g, £12 1s. per ton. Throughout the district tin-plate has remained fairly brisk, the only modifying condition being the action of the Conciliation Board. This is not regarded with much fear, and a settlement upon pacific lines is expected by the ablest authorities as certain. Thirteen steamers are due this week to load for the Far East. Outlook satisfactory.

The Swansea New Dock.

It is almost certain that the new dock will be ready for opening early in October. The approaches to the coal hoists form the most important work now proceeding. One of the Midland's tips is well in hand.

The Fusion Bills.

Considerable opposition is yet anticipated in the Commons, and the passing in the House of Lords is regarded as a preliminary to a stormy time. Notices have been given of half a dozen motions against each Bill. Mr. Richard Bell, General Secretary Amalgamated Society of Railway Servants, will move, regarding the Cardiff Railway Vesting Bill, "That it be read a second time upon this day three months." This would be equivalent to rejection. Motions in similar terms stand in the names of Mr. Lewis Haslam, Mr. Brunner, Sir Ivor Herbert, Mr. Hardie, and Mr. Harwood. Motions in the same terms are placed, we find, in opposition to the Rhymney Railway Vesting bill in the name of Mr. R. Bell and others.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

The Siegerland Iron Trade.

THE old complaint of weak quotations and insufficient occupation in most trades continues. In the iron ore department a specially dull condition appears to prevail, and although the working hours have been restricted, output is still higher than consumption.

Iron and Steel in Silesia.

In several branches of the iron industry a revival could be felt, and activity has been fairly strong during this week and the last, while in other departments less has been done than before, and orders have to be taken at very low rates. According to the *Breslauer Zeitung*, the Silesian ironmasters have expressed themselves strongly in favour of an Upper Silesian Steel Convention.

Rheinland-Westphalia.

The iron and steel works of the district are only partially well employed, the demand for most articles remaining quiet. Sales of the Steel Convention are stated to have been for May of present year 377,718 t., as compared with 364,669 t. in April of present year, and as compared with 414,855 t. in May, 1908. This shows deliveries to have been 13,049 t. higher than in April of present year, and 37,137 t. lower than in May, 1908. Of the deliveries in May 112,418 t. fall to semi-finished steel, as compared with 109,340 t. in April of present year, and as against 114 599 t. in May, 1908; railway material, 116,863 t., as compared with 123,881 t. in April, and 162,913 t. in May, 1908; sectional iron, 148,437 t., as against 131,448 t. in April of present year, and as against 137,343 t. in May, 1908.

German Syndicates.

On the 4th inst. the German Shipbuilding Steel Convention was prolonged for an indefinite period. A prolongation of the German Steel Castings Syndicate has not yet taken place, but prospects for a further existence of the said convention are favourable. The South German hoop mills are underquoting the Union of Rhenish-Westphalian Hoop Mills, which has already reduced its quotations to M. 120 and M. 122 50 p.t. for the third quarter.

Latest List Rates.

The following are the current quotations for iron ore, raw and finished iron, as given by the Düsseldorf 'Change on June the 4th:—Raw spathose ore, M. 10.90; roasted ditto, M. 15.50; Nassau red iron ore, M. 11.50 p.t. net at mines; spiegeleisen, 10 to 12 per cent. grade, M. 63 to M. 66; white forge pig, Rhenish-Westphalian and Siegerland brands, M. 56 to M. 58; steel iron, M. 58 to M. 60; German Bessemer, M. 59 to M. 61; basic, free place of consumption, M. 49 to M. 50; Luxemburg forge pig, free Luxemburg, M. 44 to M. 46; Luxemburg foundry pig, No. 3, M. 47 to M. 49; German foundry pig, No. 1, M. 58 to M. 60; No. 3, M. 57 to M. 61; German hematite, M. 59 to M. 61; bars in basic, M. 97 to M. 103; iron bars, M. 122.50 to M. 125; hoops in basic, M. 120 to M. 122.50; common plates in steel, M. 104 to M. 110; steel plates for boiler-making purposes, M. 114 to M. 120; sheets, M. 117.50 to M. 125; all per ton, free at works.

The German Coal Market.

A steady trade is done in coal, although substantial orders are scarce. Sales from Silesia to Austria-Hungary have increased upon the week.

The situation of the Rhenish-Westphalian coal trade is much the same as before; dry sorts of coal have been in rather better inquiry than previously. The business in coke is very dull, with no prospects of improvement in the immediate future. Briquettes sell pretty freely. It is strange to note that while inland prices for nearly all sorts of coal have been reduced, and English coal, as well as Belgian coke, is sold at lower rates in Germany now than in 1908, Bohemian brown coal can be disposed of at higher quotations than during last year.

Austria-Hungary.

The quarterly accounts given by some of the leading iron-works show profits to have been considerably lowered, partly in consequence of a general weakness in demand, but also because quotations have been reduced. The condition of the iron industry continues lifeless, and the outlook is dull. Pit coal as well as brown coal are in moderately good demand in Austria-Hungary, and prices remain firm.

The Belgian Iron Trade.

Exports in manufactured iron are very limited, and German firms frequently bear away orders that have been strongly competed for by Belgian mills. Bars are languid, and plates are more neglected than before. Rail orders from abroad are increasing, and a good trade is also done in girders. Rates for crude iron are improving; in the beginning of present month 62f. p.t. was quoted for forge pig; 67.50f. p.t. for basic; and 69f. p.t. for foundry pig. Scrap iron is neglected. Semi-finished steel shows a good deal of life, and foreign sales have been satisfactory. Dry sorts of coal are in improving request on the Belgian market. Briquettes remain depressed.

AUSTRALIAN NOTES.

(From our own Correspondent.)

THE quarterly report of the New South Wales Railways, ending March 31st last, shows an increase in gross earnings of £37,986, and the expenditure an increase of £45,924, over the corresponding period of last year. The increase in expenditure is owing to the continued increase in passenger traffic necessitating considerable additional train miles, also heavier repairs and renewals to rolling stock. The work in connection with the duplication of the line between Hornsby and Lindfield, and Hornsby and Wondabyne has made satisfactory progress. Good progress has also been made with the deviation to avoid the Lithgow Zig-zag.

	Quarter ended March 31st, 1909.		1908.
Miles open	3,500½	..	3,468½
Revenue	£ 1,219,215	..	1,181,229
Expenditure	£ 650,001	..	604,477
Train miles run	3,805,038	..	3,457,644
Earnings per train mile	6s. 5d.	..	6s. 10d.
Expenditure per train mile	3s. 5d.	..	3s. 6d.
Expenditure to earnings, per cent.	53.31	..	51.14
Passengers, number	12,971,425	..	11,954,832
Goods traffic, tons	706,358	..	576,380
Coal and coke, tons	1,250,640	..	1,349,500
Other minerals, tons	104,949	..	108,176
Live stock traffic, tons	108,876	..	107,830

New South Wales Tramways.—The earnings show an increase of £20,781 over the corresponding quarter of last year, and the expenditure an increase of £19,375. There were 3,515,819 additional passengers carried, and 453,456 additional tram miles were run.

	Quarter ended March 31st, 1909.		1908.
Miles open	148½	..	131
Revenue	£ 285,040	..	264,318
Expenditure	£ 215,631	..	196,256
Tram miles run	4,881,207	..	4,427,751
Earnings per tram mile	1s. 2d.	..	1s. 2¼d.
Expenditure per tram mile	10¼d.	..	1s. ¼d.
Expenditure to earnings, per cent.	75.63	..	74.25
Passengers carried, number	48,437,332	..	44,922,013

LAUNCHES AND TRIAL TRIPS.

SAGA, steel screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Thule Steamship Company of Gothenburg; dimensions, 322ft. by 46ft. beam; engines, triple-expansion, constructed by the builders; trial trip, June 10th.

PAULINA, steel screw steamer; built by Sir Raylton Dixon and Co.; to the order of Modesto Pineiro and Co., of Santander, Spain; dimensions, 300ft. by 47ft. 3in. by 22ft. 3in.; engines, triple-expansion, 21½in., 36in., 59in. by 36in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company, Limited; trial trip, June 12th.

CLEARFIELD, oil tank steamer; built by the Tyne Iron Shipbuilding Company, Limited; dimensions, 360ft. by 42ft. 6in. by 30ft. 6in.; to carry 6500 tons; engines, triple-expansion, 26in., 43in., 70in. by 48in. stroke; constructed by the Wallsend Slipway and Engineering Company; trial trip, June 14th.

NAVAL ENGINEER APPOINTMENTS.

THE following appointments have been made by the Admiralty:—

Engineer-Commanders.—J. T. Willoughby, to the Vivid, additional, for the Collingwood, and to assist on Staff of Admiral Superintendent; W. H. James to be First Assistant to Manager of Engineering Department, Portsmouth Yard; G. W. Baldwin, to be First Assistant to Manager of Engineering Department, Chatham; C. E. Eldred, to the Hermione.

Engineer-Lieutenants.—H. M. Cave-Browne-Cave, to the Indomitable, and H. H. Carter, to the Inflexible, both lent for training; G. J. Sisley, to the Vivid, supernumerary; F. Guyer, to the Pembroke, supernumerary; W. A. Donovan, to the Sirius; J. G. Budge, to the Goliath; F. Guyer, to the Sappho; W. S. Torrance, to the Hawke, temporary for manœuvres; G. J. Sisley, to the Niobe; C. E. Stone, to the Andromeda; R. J. Brown, to the Crescent, lent; F. Morrison, to the Diadem, and F. W. Hamblin, lent, all temporary, for manœuvres; J. J. Sargent, to the Controller's Department, Admiralty; C. E. M. Roe, to the Andromeda, and C. J. B. Stoneman, to the Niobe, both lent for manœuvres.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. JOHN W. BAINBRIDGE, of 2, Fen-court, Fenchurch-street, E.C., has been appointed agent in Great Britain and Ireland for the Bismarckhütte Steel Works, Berlin.

F. REDDAWAY AND CO., Limited, hose makers, of Pendleton, Manchester, and 50, 51, Lime-street, London, have recently enlarged their works for the purpose of supplying fire brigades, not only with their well-known canvas and rubber-lined hoses, but also with the latest pattern fire-extinguishing apparatus. New premises have just been opened at 212, Shaftesbury-avenue, W.

CONTRACT.—The burgh of Partick have placed an order with the Lancashire Dynamo and Motor Company, Limited, for one 1000-kilowatt Belliss L.D.M. set, complete with condenser, cooling tower, and the necessary pipework.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

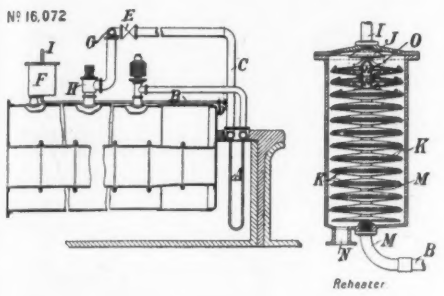
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM GENERATORS.

16,072. July, 1908.—IMPROVEMENTS IN STEAM GENERATING PLANT, Noel Newall Haigh, of Heath Bank, Watersheddings, Oldham, Lancaster.

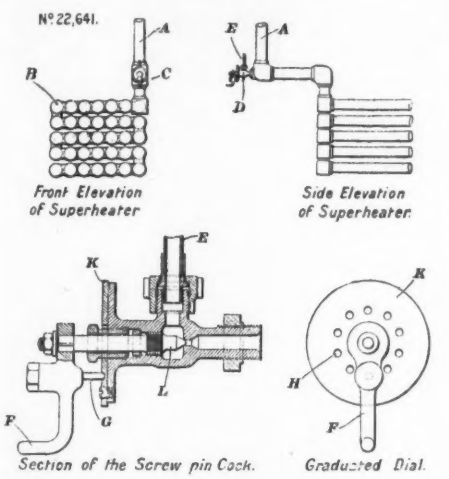
This invention relates to steam generating plant, and has for its object to provide in an economical manner for the raising of the boiler feed-water to a high temperature before it enters the boiler, and for the superheating of the steam to be supplied to the engine to a sufficient extent to prevent cylinder condensation. A superheater A is arranged in the boiler flues. The delivery from the superheater is caused to flow, by pipes or conduits B C, fitted with regulating or control valves at D and E, to a reheater F and to the pipe main G between the boiler stop valve H and the equivalent valve of the engine. The reheater consists preferably of a cylindrical vessel, fitted with a pipe I, through which the feed-water is



admitted. The lower end of the pipe I is open, and is provided with a distributing head J. Below the head a number of discs K are fitted to the central superheated steam pipe M, such discs being alternately of a convex and a concave form, and arranged so that the water flowing out from the distributing rose or head on the pipe I is caused to flow over the discs in a thin film or stream, and thus pass in a circuitous manner, as indicated by the arrows, and in an attenuated form, from the upper to the lower end of the reheater, whence it passes through the outlet N into the boiler. But immediately on issuing from the pipe I and throughout its descent of the reheater the feed-water is directly exposed to, or mingles with, the superheated steam, which is admitted through apertures O in the pipe M, and completely fills or charges the reheater at boiler pressure during the whole time that it is in communication with the superheater. The connection with the superheater is preferably at the bottom of the reheater, as shown, in order that the hottest superheated steam shall meet the hottest water within the reheater.—*June 2nd*, 1909.

22,641. October 24th, 1908.—IMPROVED METHOD OF REGULATING THE SUPERHEATING OF STEAM AND APPARATUS THEREFOR, *Louis Marie Gabriel Delaunay Belleville, of* 17, *Boulevard Richard Wallace, Neuilly-sur-Seine* (*Seine*), *and* 83, *Boulevard de Courcelles, Paris.*

The process which forms the object of the present invention consists in injecting water at the inlet to the superheater by means of a pin cock closing an orifice of small diameter, and, by means of a screw thread, permitting of obtaining apertures progressing by successive fractions, which may be as small as necessary. The water injected may be taken from the feed-water heater, if there be one, or from any point on the delivery chamber or pipe of the feed pump. The pipe A conducts the steam from the generator to the superheater B. Upon the elbow C there is mounted a screw pin cock D presenting a small orifice, and which, by means of the pipe

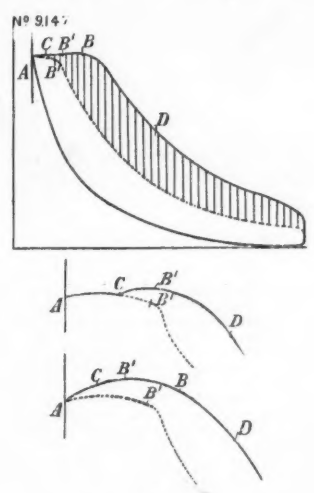


E, is supplied with water, which may come either from a feed-water heater or directly from the delivery chamber or heater of the feed pump. A hand wheel or handle F serves for opening the cock; the finger G engages in notches H in the graduated dial K and holds the cock open. When the control is automatic the finger G is dispensed with. A thermometer is arranged either at the outlet of the superheater or where the steam is admitted to the engine. When this thermometer indicates a temperature in proximity to the predetermined upper limit, the cock L is opened to the extent of one division. The water is injected into the superheater; the steam carries it along, pulverises it, and the superheater vaporises it. As soon as the fresh steam formed reaches the outlet of the superheater the thermometer indicates a slackening in the increase of temperature; then the temperature remains stationary, and finally falls. If the reduction of temperature obtained is not sufficient, the pin cock is set at the second notch, and so on in succession until the desired result has been obtained. By appropriately regulating the quantity of water injected into the superheater the temperature of the steam may be kept within limits which are close enough for practical purposes.—*June 2nd*, 1909.

INTERNAL COMBUSTION ENGINES.

No. 9147. April 27th, 1908.—IMPROVEMENTS IN INTERNAL COMBUSTION ENGINES FOR OVERCOMING AN OVERLOAD, *Ugo Tessarotte, of* 15, *Via Dante, Milan, Italy*

This invention relates to internal combustion engines, and has for its object to provide an improved method of increasing the efficiency of the same when under overload. In all three engravings the dotted expansion line represents the working diagram furnished by the engine in normal working without the increased power attainable by the invention, the admission of the normal charge of fuel beginning at A after the compression of the air is finished and, under normal load, being terminated at B^1. When under overload, compressed air alone is introduced to increase the working efficiency—see middle diagram—the admission of compressed air begins at the point C—that is to say, during the normal admission of fuel. The pressure curve rises owing to the admission of the compressed air, so that, as shown in the middle

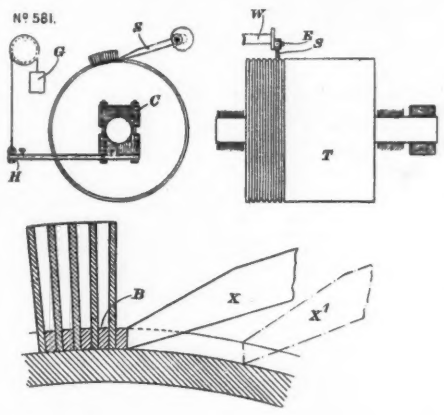


diagram, a sharp bend is formed at C, the curve then rising a little. The admission of fuel ends at the point B^1, which is projected on the raised curve in an approximately vertical direction from the normal pressure curve. The admission of the compressed air terminates at the point D. The top and bottom diagrams represent the course of the pressure curve under overload with the admission of auxiliary compressed air and auxiliary fuel according to the invention. Since here the admission of the fuel is accelerated from the start, the pressure curve rises from the point A above the course of the highest normal load. The admission of the normal fuel charge for full load continues up to point B^1, whereupon the admission of the auxiliary fuel begins, without any interval, and continues to point B of the curve. The compressed air admission begins at point C, but as shown in the bottom diagram the points C and B^1 in this case are nearer to A than when compressed air alone is introduced as in the middle diagram. The admission of compressed air continues up to the point D. The regulation of the efficiency can be effected in this case by any convenient means, either by regulating the admission of fuel or compressed air, or both.—*June 2nd*, 1909.

TURBINES.

581. January 9th, 1909.—IMPROVEMENTS IN OR RELATING TO APPARATUS FOR FIXING BLADES, *Johannes Joachim Dahl, of Gross Flottbeck, near Hamburg.*

The turbine drum T, having several grooves therein, is to be provided with blades, which are divided from one another by distance pieces B. The shaft of the drum is supported in bearings, and is provided with a brake C, the lever H of which is loaded by means of a weight G. Parallel to the axis of the drum there is supported a shaft W, which at one end is provided with a disc carrying an eccentric pin E. The excentric pin E has pivoted to it a pressing or caulking tool S, the point of which fits in the

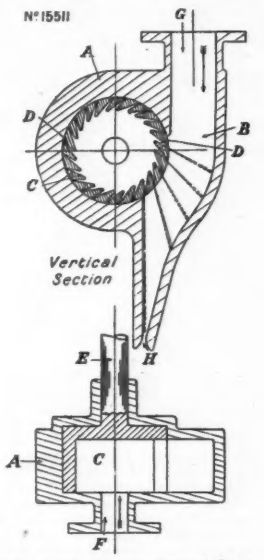


grooves of the turbine drum, and is adapted to press against the blades and distance pieces. When the shaft W rotates, the pressing tool is reciprocated in a substantially tangential direction between the positions X and X^1. In the position X^1 the blades and distance pieces are inserted. During the motion from the position X^1 to the position X these blades are firmly pressed by the tool. In consequence of the constant braking force exerted on the axis of the drum by the brake B, the pressure of the tool S is always the same, and this pressure may be adjusted by adjusting the brake. In all cases the pressure of the tool S on the distance pieces must be sufficient to upset the blade root and distance piece. When this pressure is reached, the drum T is caused to rotate through a short distance by the further motion of the tool S. It will be seen that this further rotation is effected by overcoming the resistance which is applied to the drum by means of the brake, and that this resistance is at least as great as the pressure necessary to upset the parts to be fixed in the groove. When starting to insert a ring or crown of blades, a wedge is inserted in the groove in the usual manner, and the first blade butts against the wedge. When the crown of blades is almost completed, a bent tool may be used for inserting a few of the last blades, while the remaining blades are, of course, inserted by hand in the usual manner. There are several modifications and ten illustrations.—*June 2nd*, 1909.

PUMPING AND BLOWING MACHINERY.

15,511. July 22nd, 1908.—IMPROVEMENTS IN AIR PUMPS, Charles Day, general manager of the Mirrlees Watson Company, Limited, 45, Scotland-street, Glasgow, Scotland.

This invention relates to air pumps for exhausting air or other gases from steam condensers or other chambers. It is also applicable to the compression of air or other gases to pressures higher than that of the atmosphere. In both the engravings A is a casing forming the chamber B and containing the rotating drum C, in the rim of which are formed the ducts D. The rotating drum has its axis E carried in a suitable manner through the

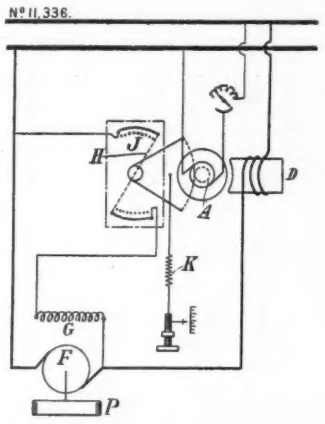


casing A, so that convenient means of rotating it may be applied The liquid enters the casing at the opening F, whence it passes to the interior of the drum C. From this drum it is discharged through the ducts D, as the outlets to these are uncovered during rotation. The liquid is therefore projected across the chamber B in sheets or curtains, the ducts being so formed as to project the liquids in sheets or curtains. As the drum revolves, each sheet or curtain of liquid is moved down the chamber B, and thus acts as a piston, and causes an inducing effect which therefore tends to exhaust air or gas from any vessel or space with which the entrance G to the chamber is put into connection. As each sheet of liquid reaches the outlet end of the chamber, the air or gas contained between that sheet and the preceding sheet is discharged through the outlet H. The energy contained in the moving streams of liquid being the source of power for discharging against a higher pressure than prevails in the chamber.—*June 2nd*, 1909.

DYNAMOS AND MOTORS.

11,336. May 25th, 1908.—IMPROVEMENTS IN CONNECTION WITH DYNAMO-ELECTRIC MACHINERY SUBJECT TO FLUCTUATION OF LOAD, the Electric Construction Company, Limited, of Bushbury Works, Wolverhampton, in the County of Stafford, and William Buchanan, of the same address.

This invention relates to an improved automatic regulator for varying the field excitation of dynamo-electrical machinery subject to fluctuation of load, and is especially intended for use in connection with electrically operated rolling mill or other plant in which a fly-wheel, or the equivalent, is employed in regulating the operation of the machinery, but the invention is not limited thereto. The armature A of the auxiliary motor is driven by

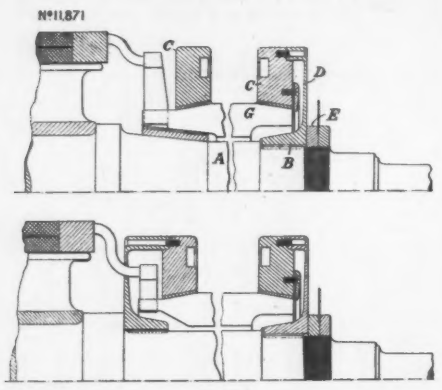


current from the mains, and the field magnets—indicated at D—of the motor are excited by current passing from the mains to the motor F. In series with the field winding G of the motor F is a spring or weight-controlled rheostat, which is operated from the armature spindle of the auxiliary motor, for instance, by a pinion keyed on the spindle gearing, with a quadrantal rack keyed on the axis of the lever arm H of the rheostat J, the rheostat arm H being acted upon by a force, such as by a spring K, acting on the quadrantal rack, or by a hanging weight. When the current taken by the motor F increases, the torque of the auxiliary motor A will increase, owing to the increased current passing round its field magnets D, and the lever arm H of the rheostat J will be operated so as to remove resistance from the rheostat and increase the exciting current of the motor F, and thus cause the speed to diminish, and the fly-wheel K will give up some of its stored energy. When the current taken by the motor F falls below the average amount, the torque of the

motor A will diminish, and the weight, or the spring, will overcome this decreased torque and operate the lever arm H of the rheostat J, so that more resistance will be put in the exciting circuit of the field G of the motor F, thus increasing the speed thereof, and restoring energy to the fly-wheel K.—*June 2nd*, 1909.

11,871. June 1st, 1908.—IMPROVEMENTS IN AND RELATING TO COMMUTATORS FOR DYNAMO ELECTRIC MACHINES, The Honourable Charles Algernon Parsons, C.B., and Alexander Henry Law, both of Heaton Works, Newcastle-on-Tyne.

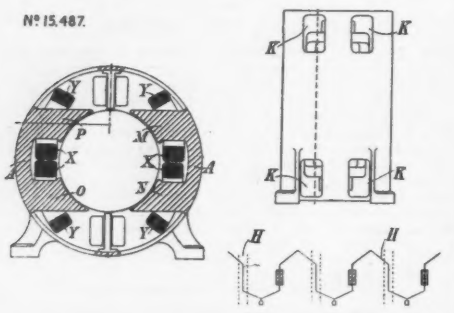
The object of the present invention is to support the commutator or other part to which the invention is applied in such a manner that it can expand without danger of jamming or becoming loose or throwing undue stresses on the shaft. The invention consists in providing means for allowing the commutator to expand longitudinally without the use of sliding metallic surfaces, by supporting one or both ends on a suitable structure which possesses considerable strength radially and is capable of deformation in an axial direction. In carrying the invention into effect



according to one modification the commutator bars are supported strongly by means of rings internally of conical form, insulation being placed between the rings and the commutator bars. The commutator bars are disposed around the armature shaft in the usual manner. As shown on the outer end of the shaft A, there is provided a steel diaphragm D, on a strong hub B, which is threaded over the armature shaft and keyed thereon. The diaphragm D is bolted or otherwise attached firmly to the outer one of the rings C, fitting on the commutator bars G, and thus supports the outer end of the commutator. The hub of the diaphragm is held in position by means of a nut E, preferably so placed as to exert a constant pressure on the commutator towards the armature windings. The inner end of the commutator may be similarly supported by a diaphragm with holes in it to pass the commutator connections as shown in the lower engraving or the connections may be carried outside the diaphragm, or the commutator may be supported on a cone in the usual way. The flexible diaphragm or diaphragms may be mounted on a sleeve, threaded and keyed on to the shaft. There are several modifications.—*June 2nd*, 1909.

15,487. July 21st, 1908.—IMPROVEMENTS IN DYNAMO-ELECTRIC MACHINES, John Wesley Burleigh, of Hazeldene, Leslie-street, Rowbarton, Taunton, Somersetshire.

This invention relates to improvements in dynamo-electric machines by means of which sparking at the commutator and magnetic leakage is reduced, and at the same time good ventilation is provided for. A A are field magnets united by the yoke. On the limbs M. N, O and P of these (M and O being, say, S poles and N and P N poles) are mounted the main field coils. As will be seen, the main field coils are arranged so that a part X of each

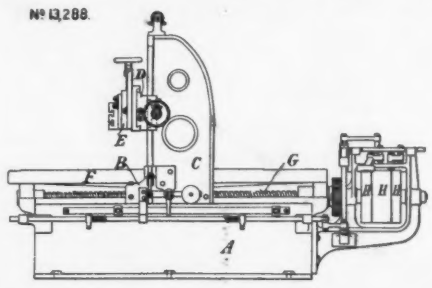


lies in the neutral zone directly over and parallel, or nearly parallel, to the coils of the armature which at the time are undergoing commutation. Placing the field coils in this position essens the self-induction of armature coils undergoing commutation and reduces magnetic leakage. The opposite parts Y of the main field coils are placed as shown so as to leave a considerable space between them. In this space commutating or reversing poles are placed with their coils. It is to be noted that the angle between the axis of a main pole core and the axis of a commutating pole is equal to 360 deg. divided by the number of main poles. This arrangement of the main and commutating pole cores is a distinctive feature of the invention, and it permits of these parts of the main coils which lie in the neutral zone being conveniently brought very close to the coils of the armature which at the time are undergoing commutation. The arrangement of poles and windings is shown diagrammatically in which the full line represents a winding of a series wound armature, the dotted lines H the portions of the field coils and the rectangles the commutating poles. As only a comparatively small mass of metal is required in the yoke for carrying the main flux, in fact only what is passing through the commutating poles, this yoke may safely be cut away at the parts K so as to provide ventilating holes through which air may pass for cooling purposes.—*June 2nd*, 1909.

MACHINE TOOLS AND SHOP APPLIANCES.

13,288. December 18th, 1908.—PLANING MACHINE FOR PLANING AND MACHINING IRON, STEEL, BRASS AND OTHER MATERIALS John William Pitt, engineer, Newlands, Newlands-park, Sydenham, London, S.E.

This invention relates to planing machines in which the tables or buffits are fixtures or stationary, consequently the articles fixed thereon to be machined remain stationary during the process of being machined. These machines have a bed with surfaced slide, the full length on which is mounted a carriage which travels or traverses the full length of the bed by means of nut and screw or rack and pinion and worm gear, and on this carriage are fixed the

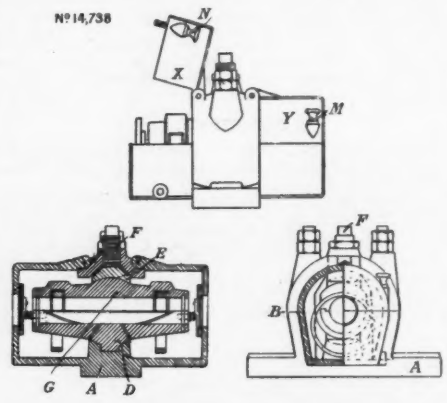


two uprights to which the cross slide and tool-boxes are secured. According to the invention the travelling carriage, to which the uprights and cross slide with tool-boxes are fixed, is directly under the stationary table on which the articles to be machined are secured and is driven by a screw centrally placed. A is the bed, B is the carriage, C is the right-hand upright, D is the cross slide, E is the tool-box, F is the stationary table, G is the driving screw, H H H are three pulleys; the two outside pulleys are loose and the centre pulley is the driver which actuates the screw that traverses the carriage on the bed; there are one cross belt and one straight belt provided with automatic shifting motions for reversing the traverse of the carriage at any point or distance to suit the length of the article or articles that are being machined.—*June 2nd*, 1909.

MISCELLANEOUS.

14,738. July 11th, 1908.—IMPROVEMENTS IN RING LUBRICATING BEARINGS, *Hermann Stams, Bad Warmbrunn, Prussia.*

This invention relates to an improved dust-tight ring lubricating bearing with movable steps which, while being of strong, solid construction, can be readily inspected and adjusted during revolution of the shaft. The invention is illustrated in the accompanying engraving, in which by way of example a pedestal bearing is shown. A is the pedestal base, formed in one piece with the body B, which constitutes an oil reservoir. The base presents a concave bed to accommodate the lower bearing part or step D. The upper bearing part or step E presents a convex



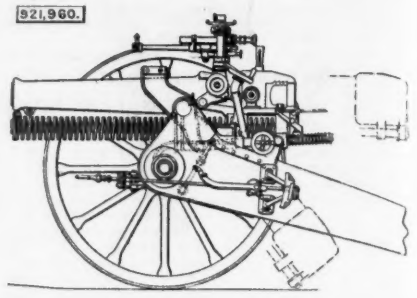
facing which is received by the concave tail piece of an adjusting screw F, passing through the cap. By adjusting the screw F wear can be taken up, or the step G tightened after having been trued up subsequent to long use. To the cap there are hinged two covers, X Y, which admit of ready inspection of the bearing at any moment. The covers can be held down dust-tight by means of screws M N. The shaft passes through the two ends of the oil reservoir B, and to prevent friction in the event of shocks in the end apertures and at the same time to form a safe dust-tight joint, special split packing rings are employed. Should the bearing get hot, owing to scarcity of oil, wearing down or catching of the oil rings, or the like, the defect can be quickly remedied after opening the covers. There is thus no need to stop work for the purpose of refilling the oil reservoir, inserting a new oil ring, or inspecting the bearing for any reason.—*June 2nd*, 1909.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

921,960 BREECH-LOADING ORDNANCE, *A. T. Dawson and G. T. Buckham, Westminster, London, England, assignors to Vickers, Sons and Maxim, Limited, London, England.—Filed August 14th*, 1907.

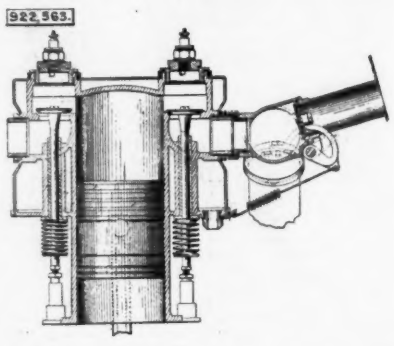
This is a combination patent for a gun to give high-angle fire. It includes the combination with the gun and its cradle, trunnioned in the carriage, of an elevating arm adapted to rock about the axis



of the trunnions, a loading screw and an elevating screw connected with this arm, toothed gearing carried by the cradle for imparting motion to the loading screw, toothed gearing carried by the carriage for imparting motion to the elevating screw, means for actuating the toothed gearing, and means for ensuring the return of the gun, after loading, to the position to which it had been previously adjusted by the elevating screw. There are nine claims.

922,563. MUFFLER CUT-OUT MECHANISM, *L. S. Chadwick, Pottstown, Pa.—Filed March 8th*, 1909.

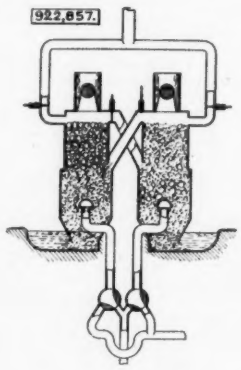
This patent is for an exhaust manifold, with suitable muffler, a plurality of discharge ports opening laterally from the manifold, a



rock shaft journalled below these ports, curved arms on the rock shaft projecting into the ports, valves mounted on the ends of the arms, and means for rocking the shaft to cause the arms to carry the valves into the bottom of the manifold to open the exhaust ports. There are four claims.

922,857. PROCESS OF MANUFACTURING GAS, *W. H. Cone, Detroit, Mich., assignor to the Coal Products and Power Company, Detroit, Mich., a Corporation of Michigan.—Filed July 3rd*, 1908.

There are seven claims. The fourth runs as follows:—The process of generating gas which consists in blasting alternately



through two bodies of coked fuel to maintain the same incandescent, in placing green fuel adjacent and in coking proximity to one of said bodies of incandescent fuel but out of the path of the blast, in passing the distillate from said green fuel into the adjacent incandescent fuel, and in simultaneously passing into said incandescent fuel and commingling with said distillate of the hot blast gases from the other mass of incandescent fuel.

END OF VOL. CVII.